

C3 chapter 1: the periodic table

1. 1. Properties and atomic weights

2. 2. Protons had not been discovered yet.

3. 3. The total number of Protons and Neutrons an atom has.

4. 4. The law of Octaves, which stated that every eighth element had similar properties.

5. 5. He left gaps for undiscovered elements so that the group of known elements did have similar properties

6. 6. Mendeleev

7. 7. At the start of the 20th Century.

8. 8. They were now arranged in order of their atomic numbers and were lined up in vertical groups.

9. 9. Groups are columns in the table and Periods are the rows in the table

10. 10. Going down Group 1, the reactivity increases. Going down Group 7, the reactivity decreases.

11. 11. Alkali metals.

12. 13. Low melting and boiling points, soft, low densities, react quickly with water producing hydroxides and hydrogen gas.

14. 14. Metal + Water -> Metal Hydroxide + Hydrogen. They form Alkaline solutions when they react with water.

15. 15. 1

16. 16. Colourless

17. 17. Between group 2 and 3. They are malleable, good conductors of heat and electricity. Most are strong and dense.

18. 18. Halogens, they exists as small molecules made up of pairs of atoms.

19. Describe group 7 properties.

19. Low melting point and boiling point.

How many groups are there to classify the elements?

How many periods are there as you go down the

This question is about atomic structure and elements.

(a) Complete the sentences.

(i) The atomic number of an atom is the number of

protons

(1)

allow "protons or electrons", but do not allow "protons and electrons"

(ii) The mass number of an atom is the number of

protons plus / and neutrons

(1)

(b) Explain why an atom has no overall charge.

Use the relative electrical charges of sub-atomic particles in your explanation.

(because the relative electrical charges are) $-(1)$ for an electron and $+(1)$ for a proton

allow electrons are negative and protons are positive

and the number of electrons is equal to the number of protons

if no other mark awarded, allow 1 mark for the charges cancel out

(2)

(c) Explain why fluorine and chlorine are in the same group of the periodic table.

Give the electronic structures of fluorine and chlorine in your explanation.

(the electronic structure of) fluorine is 2,7 and chlorine is 2,8,7

allow diagrams for the first marking point

1

(so fluorine and chlorine are in the same group) because they have the same number of or 7 electrons in their highest energy level or outer shell

if no other mark awarded, allow 1 mark for have the same / similar properties

1

(2)

The diagram shows the chemical symbols of five elements in the periodic table.

Group 1		2												3	4	5	6	7	0
																		He	
Na																			

(a) Choose the correct chemical symbol to complete each sentence.

(i) The element that is an alkali metal is ...

Na

allow sodium

(1)

(ii) The element that is a transition metal is ...

Cu

allow copper

(1)

(iii) The element in Group 4 is ...

C

allow carbon

(1)

(iv) The element with a full outer energy level (shell) of electrons is

He

allow helium

(1)

(b) Which other element goes in the shaded box?

H

allow hydrogen

do not allow H₂

(1)

(Total 5 marks)

In 1866 John Newlands produced an early version of the periodic table.

Part of Newlands' periodic table is shown below.

Column	1	2	3	4	5	6	7
	H	Li	Be	B	C	N	O
	F	Na	Mg	Al	Si	P	S
	Cl	K	Ca	Cr	Ti	Mn	Fe

Newlands' periodic table arranged all the known elements into columns in order of their atomic weight.

Newlands was trying to show a pattern by putting the elements into columns.

(a) Iron (Fe) does **not** fit the pattern in column 7.

(iron) is a metal
accept transition element
allow (iron) had different properties (to oxygen and sulfur)
ignore electrons

(1)

(b) In 1869 Dmitri Mendeleev produced his version of the periodic table.

Why did Mendeleev leave gaps for undiscovered elements in his periodic table?

so that elements with similar properties could be placed together
allow to make the pattern fit
ignore undiscovered elements

(1)

(c) Newlands and Mendeleev placed the elements in order of atomic weight.

Complete the sentence.

The modern periodic table places the elements in order of

atomic number(s)
allow proton number(s)

(1)

(d) Lithium, sodium and potassium are all in Group 1 of the modern periodic table.

Explain why.

all have one electron in the outer shell (highest energy level)
allow same number of electrons in the outer shell (highest energy level)

1

(so they) have similar properties
or
react in the same way

allow specific reactions e.g. with water

1

This question is about the halogens (Group 7).

(a) How do the boiling points of the halogens change down the group from fluorine to iodine?

.....
increase
.....

(b) Sodium bromide is produced by reacting sodium with bromine.

Sodium bromide is an ionic compound.

(i) Write down the symbols of the **two** ions in sodium bromide.

.....
Na⁺ and Br⁻
both required
.....

(ii) Chlorine reacts with sodium bromide solution to produce bromine and one other product.

Complete the word equation for the reaction.

chlorine + sodium bromide → bromine + **sodium chloride**
allow NaCl
*do **not** allow sodium chloride*

(iii) Why does chlorine displace bromine from sodium bromide?

.....
chlorine is more reactive than bromine
allow converse argument
allow symbols Cl, Cl₂, Br and Br₂
allow chlorine / it is more reactive
*do **not** allow chloride **or** bromide*
.....

(1)

(1)

(iv) Use the Chemistry Data Sheet to help you to answer this question.

Suggest which halogen could react with sodium chloride solution to produce chlorine.

.....
fluorine
allow F / F₂
*do **not** allow fluoride.*
.....

(1)

(1)

The positions of eight elements in the modern periodic table are shown below.

Group	1	2									3	4	5	6	7	0
	Li												N			
											Al					
	K						Fe			Cu			As		Br	

Choose the correct chemical symbols to complete each sentence.

- (a) The **two** metals that react vigorously with water are

Li and K

either order

*allow lithium **and** potassium*

(1)

- (b) The element used as a catalyst in the Haber process is ...

Fe

allow iron

(1)

- (c) The **two** elements with five electrons in their outer shell (highest energy level) are ...

N and As

either order

*allow nitrogen **and** arsenic*

(1)

- (d) Iron has ions with different charges.

The other metal that has ions with different charges is ...

Cu

allow copper

(1)

(Total 4 marks)

Use the periodic table and the information in the table below to help you to answer the questions.

The table shows part of an early version of the periodic table.

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
H						
Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl

(a) Hydrogen was placed at the top of Group 1 in the early version of the periodic table.

The modern periodic table does **not** show hydrogen in Group 1.

(i) State one **similarity** between hydrogen and the elements in Group 1.

any **one** from:

- one electron in the outer shell / energy level
- form ions with a 1+ charge

(1)

(ii) State one **difference** between hydrogen and the elements in Group 1.

any **one** from:

- hydrogen is a non-metal
 - (at RTP) hydrogen is a gas
 - hydrogen does not react with water
 - hydrogen has only one electron shell / energy level
 - hydrogen can gain an electron **or** hydrogen can form a negative / hydride / H⁻ ion
 - hydrogen forms covalent bonds **or** shares electrons
- accept answers in terms of the Group 1 elements*

(1)

(b) Fluorine, chlorine, bromine and iodine are in Group 7, the halogens.

The reactivity of the halogens decreases down the group.

Bromine reacts with a solution of potassium iodide to produce iodine.



(i) In the reaction between bromine and potassium iodide, there is a reduction of bromine to bromide ions.

In terms of electrons, what is meant by reduction?

(bromine) gains electrons

it = bromine

*do **not** accept bromide ion gains electrons*

ignore loss of oxygen

(1)

(ii) Complete the half equation for the oxidation of iodide ions to iodine molecules.



(2)

(iii) Explain, in terms of electronic structure, why fluorine is the most reactive element in Group 7.

fluorine is the smallest atom in Group 7 **or** has the fewest energy levels in Group 7 **or** has the smallest distance between outer shell and nucleus

*the outer shell **must** be mentioned to score 3 marks*

1

fluorine has the least shielding **or** the greatest attraction between the nucleus and the outer shell

1

therefore fluorine can gain an electron (into the outer shell) more easily

1

(3)

This question is about the periodic table of elements.

Use the Chemistry Data Sheet to help you to answer these questions.

In 1869 Dmitri Mendeleev produced an early version of the periodic table.

(a) Draw a ring around the correct answer to complete each sentence.

(i) Mendeleev first arranged the elements in order of their

atomic weight

date of discovery.
electron number.

(1)

(ii) Mendeleev then placed elements with similar properties in columns called

groups

periods.
shells.

(1)

(iii) When the next element did not fit the pattern,

Mendeleev

ignored the element.

left a gap

put the element at the end of the row.

(1)

(iv) Mendeleev was not able to include the noble gases (Group 0) in his periodic table

because the noble gases

are not elements.

are not reactive

had not been discovered by 1869

(1)

(b) Use the correct word from the box to complete each sentence.

electrons

molecules

neutrons

protons

In the modern periodic table elements are arranged in order of the number of

protons

in their nucleus. Elements in the same group have the same

number of electrons in their highest energy level (outer shell).

(2)

(c) Sodium (Na) is in Group 1 of the periodic table.

Nickel (Ni) is a transition element.

Tick (✓) **two** correct statements about sodium and nickel.

Statement	Tick (✓)
sodium and nickel are both metals	<input checked="" type="checkbox"/>
Sodium has a higher melting point than nickel.	<input type="checkbox"/>
sodium is more reactive than nickel	<input checked="" type="checkbox"/>
Sodium is harder than nickel.	<input type="checkbox"/>

(2)

(d) Chlorine, bromine and iodine are in Group 7 of the periodic table.

Chlorine is more reactive than bromine.

(i) Complete the word equation for the reaction between chlorine and sodium bromide.

chlorine + sodium bromide → bromine + sodium chloride

(1)

(ii) Why does iodine **not** react with sodium bromide solution?

iodine is less reactive (than bromine)

it = iodine

allow converse

do **not** allow bromide

(1)

In 1869, Dmitri Mendeleev produced his periodic table of the elements.

Mendeleev placed the alkali metals in the same group.

(a) What evidence did Mendeleev use to decide that the alkali metals should be in the same group?

similar properties

allow same properties

allow correct example of property

ignore answers in terms of atomic structure

(b) Describe how the elements in the modern periodic table are arranged:

(i) in terms of protons

in order of atomic / proton number

allow increasing number (of protons)

(ii) in terms of electrons.

elements in same group have same number (of electrons) in outer shell **or**
highest energy level

allow number (of electrons) increases across a period

(c) State **two** properties of transition elements that make them more useful than alkali metals for making water pipes.

any **two** from:

statements must be comparative

- stronger / harder

ignore higher densities

- less reactive
- higher melting points

ignore boiling point

(d) Describe and explain the trend in reactivity of the alkali metals (Group 1).

reactivity increases down group

allow converse throughout

*for next three marks, outer electron needs to be mentioned once
otherwise max = 2*

(1) *outer electron is further from nucleus*

allow more energy levels / shells

allow larger atoms

less attraction between outer electron and nucleus

allow more shielding

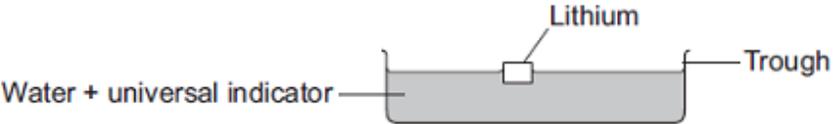
(1) *therefore outer electron lost more easily*

(1)

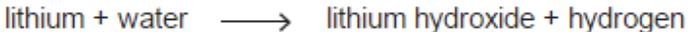
(2)

A student was investigating the reaction of lithium and water.

She added a few drops of universal indicator to water in a trough and added a piece of lithium.



The word equation for the reaction is:



(a) (i) The lithium floated on the water.

State **two** other observations that the student would **see** during the reaction.

- 1 .. any **two** from:
- 2 ..
- bubbles / effervescence / fizzing
ignore hydrogen / gas produced
 - lithium disappears / gets smaller
allow dissolves
*do **not** allow melts / burns*
 - lithium moves on the surface of the water
ignore floats
 - (universal indicator) turns blue / purple

(2)

left-hand side correct 1

right-hand side correct
allow multiples for full credit 1

(iii) Describe a simple test and the result that would show the gas was hydrogen.

light / burn, which will give a (squeaky) pop / explosion

(1)

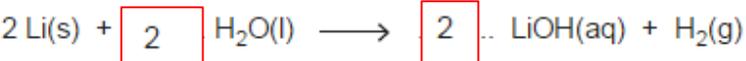
(iv) All Group 1 metals have similar reactions with water.

State why, in terms of electronic structure.

all have 1 electron in their outer shell / energy level
allow have the same number of electrons in their outer shell / energy level

(1)

(ii) Balance the symbol equation for the reaction of lithium and water.



(b) Lithium and other Group 1 metals have different properties from the transition metals.

Tick (✓) **two** properties that are properties of Group 1 metals.

They react with oxygen

1

They form coloured compounds.

They are strong and hard.

They have low melting points

1

(c) The electronic structure of a potassium atom is 2, 8, 8, 1

(i) Draw a diagram to show the electronic structure of a potassium ion.

Show the charge on the potassium ion.

electronic structure [2,8,8] is drawn

incomplete inner shells scores a maximum of 1 mark

1

charge is +

allow [2,8,8]⁺ for 1 mark

1

(ii) Potassium is more reactive than sodium.

Explain why, in terms of electronic structure.

because (in potassium) the outer shell electron is further away from the nucleus
or because potassium atoms are larger than sodium atoms

it should be clear that the candidate is referring to the outer shell electron: if this is not clear a maximum of 2 marks can be awarded

1

therefore the outer shell electron is less strongly attracted to the nucleus **or** is more shielded from the attraction of the nucleus and so the outer shell electron in potassium is more easily lost

1

3 marks can be scored for answering the question in terms of sodium

1

(2)

(3)

(2)

This question is about the periodic table.

Use the Chemistry Data Sheet to help you answer these questions.

- (a) Complete the sentences.

Elements in the periodic table are arranged in order of atomic

The elements in Group are called the noble gases.

allow 8

(2)

- (b) Calcium (Ca) is in Group 2.

Name **one** other element in Group 2.

.....
allow correct symbols

(1)

- (c) Draw a ring around the correct answer to complete each sentence.

- (i) Sodium (Na) is

(1)

- (ii) Nickel (Ni) is

(1)

- (d) In 1869 Mendeleev produced his periodic table.

Why did Mendeleev leave gaps in his periodic table?

.....
..... *accept so elements with similar properties were in the same groups*
..... *accept so elements fitted the pattern of properties*

(1)

In 1869, Dmitri Mendeleev produced his periodic table of the elements.

Mendeleev placed the alkali metals in the same group.

(a) What evidence did Mendeleev use to decide that the alkali metals should be in the same group?

similar properties

allow same properties

allow correct example of property

ignore answers in terms of atomic structure

(b) Describe how the elements in the modern periodic table are arranged:

(i) in terms of protons

in order of atomic / proton number

allow increasing number (of protons)

(ii) in terms of electrons.

elements in same group have same number (of electrons) in outer shell **or**
highest energy level

allow number (of electrons) increases across a period

(c) State **two** properties of transition elements that make them more useful than alkali metals for making water pipes.

any **two** from:

statements must be comparative

• stronger / harder

ignore higher densities

• less reactive

• higher melting points

ignore boiling point

(d) Describe and explain the trend in reactivity of the alkali metals (Group 1).

reactivity increases down group

allow converse throughout

*for next three marks, outer electron needs to be mentioned once
otherwise max = 2*

(1)

outer electron is further from nucleus

allow more energy levels / shells

allow larger atoms

1

1

less attraction between outer electron and nucleus

allow more shielding

(1)

1

therefore outer electron lost more easily

1

4)

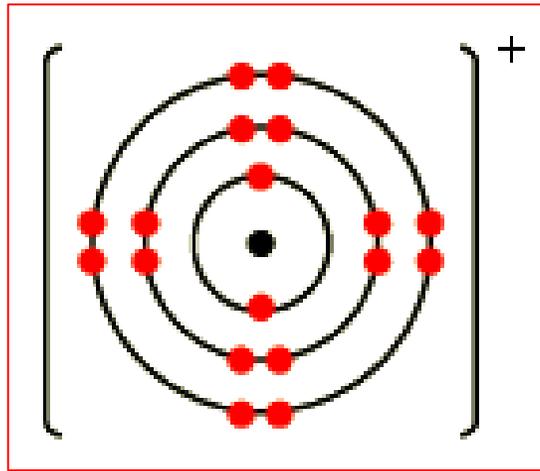
(1)

(2)

(c) The electronic structure of a potassium atom is 2, 8, 8, 1

(i) Draw a diagram to show the electronic structure of a potassium ion.

Show the charge on the potassium ion.



(2)

electronic structure [2,8,8] is drawn

incomplete inner shells scores a maximum of 1 mark

1

charge is +

allow [2,8,8]⁺ for 1 mark

1

(ii) Potassium is more reactive than sodium.

Explain why, in terms of electronic structure.

because (in potassium) the outer shell electron is further away from the nucleus
or because potassium atoms are larger than sodium atoms

it should be clear that the candidate is referring to the outer shell electron: if this is not clear a maximum of 2 marks can be awarded

1

therefore the outer shell electron is less strongly attracted to the nucleus **or** is more shielded from the attraction of the nucleus and so the outer shell electron in potassium is more easily lost

1

3 marks can be scored for answering the question in terms of sodium

1

(3)

- (a) Dmitri Mendeleev was one of the first chemists to classify the elements by arranging them in order of their atomic weights. His periodic table was published in 1869.

How did Mendeleev know that there must be undiscovered elements **and** how did he take this into account when he designed his periodic table?

.....
if placed consecutively, then elements would be in wrong group / have wrong properties

allow some elements didn't fit pattern

1

left gaps

1

- (b) By the early 20th century protons and electrons had been discovered.

Describe how knowledge of the numbers of protons and electrons in atoms allow chemists to place elements in their correct order and correct group.

(elements placed in) atomic / proton number order

1

(elements in) same group have same number of outer electrons

1

any **one** from:

- number of protons = number of electrons
- reactions/(chemical) properties depend on the (outer) electrons
- number of shells gives the period

allow number of shells increases down the group

1

- (c) The transition elements are a block of elements between Groups 2 and 3 of the periodic table.

- (i) Transition elements have similar properties.

Explain why, in terms of electronic structure.

(transition elements usually) have same / similar number of outer / 4th shell electrons

allow 2 electrons in outer shell

1

(because) inner (3rd) shell / energy level is being filled

ignore shells overlap

1

- (ii) There are **no** transition elements between the Group 2 element magnesium and the Group 3 element aluminium.

Give a reason why, in terms of electronic structure.

..... 2nd shell / energy level can (only) have maximum of 8 electrons

accept no d-orbitals

.....
or

..... 2nd shell / energy level cannot have 18 electrons

(1)

The diagram shows some of the elements in Groups 1 and 7 of the Periodic Table.

Group							0
1	2	3	4	5	6	7	
Li						F	
Na						Cl	
K						Br	
						I	

(a) The elements in Group 1 have similar chemical properties.

Describe **one** chemical reaction which shows potassium reacting in the same sort of way. You should say what you would react them with and what substances would be produced.

- What you would react them with

.....

- Substances produced

.....

.....

- (a)
- water
(allow acid*)
 - (metal) hydroxide (solution)/alkali
(allow metal salt / compound)
 - hydrogen

(b) *idea that*

- hydrogen and iodine would only react if heated to $> 200^{\circ}\text{C}$ / a high temperature (*ignore* reference to light / dark)
- reactivity decreases down the Group / iodine is lower in the Group than bromine / iodine is the lowest in the Group

(or converse N.B. credit this idea here even if given in (d))

for 1 mark each

2

(c) $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$ or $\frac{1}{2}\text{H}_2 + \frac{1}{2}\text{Cl}_2 \rightarrow \text{HCl}$

for 1 mark

1

(d) *idea that* (or converse)

- in atoms lower down the Group the electrons in the outer shell / highest energy level (of electrons) are further from the nucleus or shielded by more (inner) shells / electrons

[but not simply "more electrons"]

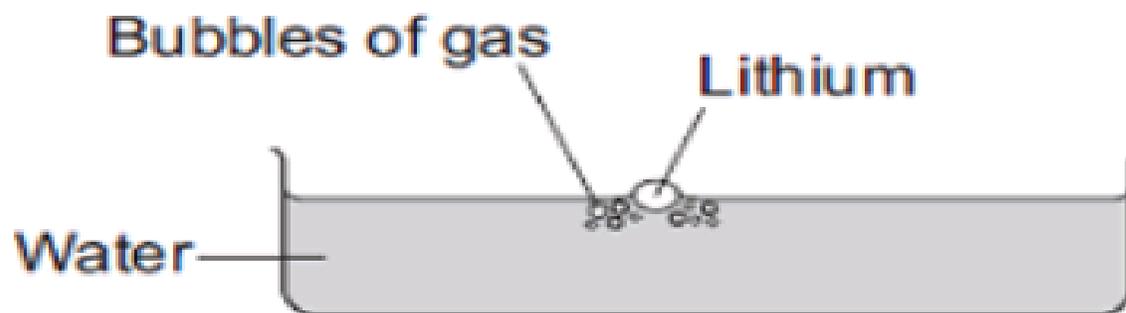
or are less strongly attracted to the nucleus

- so an electron is less easily gained

for 1 mark each

Lithium is in Group 1 of the periodic table.

Lithium reacts with water to produce a gas and an alkaline solution.



(a) (i) Name the gas produced.

hydrogen

(1)

(ii) Which ion causes the solution to be alkaline?

hydroxide

(1)

- (b) Potassium is also in Group 1 of the periodic table.
Potassium reacts with water in a similar way to lithium.

Write down **two** differences you would see between the reactions of potassium and lithium.

(b) any two from:

'it' = potassium

1

potassium:

accept converse for lithium

- reacts / dissolves faster

allow reacts more vigorously / quickly / violently / explodes

ignore reacts more

2

- bubbles / fizzes faster

allow fizzes more

allow more gas

- moves faster (on the surface)

allow moves more

- melts

(2)

(a) Draw a ring around the correct answer to complete the sentence.

In the periodic table,
as

(a) groups

(b) it is a non-metal

allow it is not a metal

groups.

1

rows.

1

(1)

(b) Suggest **one** reason why hydrogen should **not** have been put in column 1.

.....

(1)

Sodium compared with iron	Tick(✓)
sodium	(a) sodium has a lower density 1
sodium	sodium is more reactive 1
sodium is harder	
sodium is more reactive	
sodium is softer	

(2)

- (ii) Mendeleev was able to make predictions about the undiscovered elements.
This eventually led most scientists to accept his table.

Suggest what predictions Mendeleev was able to make about these

(ii) predicted they were metals

allow atomic mass / weight

ignore atomic structure

1

predicted their (chemical/physical) properties / reactivity

accept any chemical / physical property

allow similar properties if mentioned in context of a group

1

(2)

(b) Platinum and gold have properties that make them suitable for wedding rings.

Tick (✓) **two** of these properties.

(b) These metals do not react with air

1

These metals do not react with water

1

	Tick (✓)
These metals have low melting points.	
These metals do not react with water.	
These metals have low densities.	

(2)

(Total 3 marks)

(b) Explain, in terms of electronic structure, why transition elements have similar chemical properties.

.....

..... (b) (transition elements have) same number / two electrons in
..... outer shell /
..... energy level / fourth shell

..... *ignore references to (metallic)*
..... *structure / bonding*

1

..... any **one** from:

..... • because lower energy level / inner shell being filled

..... • because third energy level can hold up to eighteen
..... electrons

1

[4] (2)

(Total 4 marks)

Sea water contains bromide ions (Br^-).

The bromide ions can be changed to bromine by bubbling chlorine gas into sea water.

Chlorine is able to displace bromine from sea water because chlorine is more **(b)** *must be comparative in all points or converse*



chlorine atom is smaller than bromine atom

or

chlorine atom has fewer shells than bromine atom

1



Explain, in terms
than bromine.

outer shell / energy level of chlorine has stronger
(electrostatic) attraction to
the nucleus than bromine

or

outer shell of chlorine is less shielded from the nucleus than
bromine

1

so chlorine more readily gains an extra electron

1

[4]

- (c) Today, ships are made from steel. Steels are alloys of iron, a transition metal.

Give **two** properties of transition metals that make them suitable for making ships.

Property

1

.....

Property

2

.....

(c) any **two** from:

transition elements (= they)

- unreactive / not very reactive

allow does not corrode

ignore reference to rust

- strong / hard

ignore tough / durable / hard wearing

- malleable / easy to shape

ignore ductile / density / melting point

(d) In the 20th century, the arrangement of elements in the periodic table was

Describe the link between the periodic table and the arrangement of elements in the periodic table.

(d) any **two** from:

ignore mass number / atomic weight / neutrons throughout

- elements arranged in proton / atomic number order

allow number of protons / electrons increases across period

- group: elements in same group / column have same number of outer electrons

- elements in same period / row have same number of (electron) shells / energy levels

allow number of (electron) shells / energy level increase down group

allow electron rings

allow orbits

2

[7]

(2)

How did Mendeleev know that there must be undiscovered elements and how did he take this into account when he designed his periodic table?

(a) left gaps

1

if placed consecutively, then elements would be in wrong group / have wrong properties / owtte

allow some elements didn't fit pattern

1

(2)

Sodium is a Group 1 element.

(a) (i) A small piece of sodium is added to some water containing Universal Indicator

Describe what you would see

.....

.....

.....

.....

.....

.....

.....

(a) (i) UI / solution turns blue / purple
allow violet / lilac

1

any **two** from:

- floats
- melts / forms a sphere
- moves
note: moves on surface = 2 marks (points 1 and 3)
- effervescence / fizz / bubbles / gas
ignore the name of the gas
- (yellow) flame
ignore sparks / ignites / burns
allow dissolves

3)

(b) In terms of electronic structures, explain why iodine is **less reactive** than bromine

(b) iodine is less reactive than bromine because the iodine (atom)

..... is bigger or outer electrons (level / shell) further from the nucleus

accept converse for bromine

..... 1

therefore the forces attracting an incoming electron are weaker or there is more shielding of the forces attracting an incoming electron

..... 1

therefore the outer electron gained less easily

Max 2 if no mention of outer energy level / shell or of outer electron(s)

..... 1

[5]

.....

(3)

(Total 5 marks)

Chlorine and bromine are important Group 7 elements.

(a) Explain why chlorine is used to disinfect water

.....
.....

(a) kills bacteria / sterilises (water)

*allow kills microorganisms /
microbes / germs*

*allow 'makes (water) safe (to drink)'
or disinfectant*

*ignore cleans water or removes
impurities / bacteria*

1

(1)

(b) Describe what happens when chlorine reacts with an unsaturated hydrocarbon

.....
.....

(b) goes colourless / decolourised (from red / red-brown / brown / yellow / orange)

allow colour disappears

*ignore 'goes clear' or discoloured
do not accept incorrect initial colour*

do not accept precipitate

1

(1)

Sodium Drum Blaze Scare

A 20 litre drum containing sodium burst into flames when it reacted violently with rainwater at a Manchester factory. It is believed that the sodium, which is normally stored under oil, had been accidentally left outside with the lid off.

A factory worker put out the blaze before the fire services arrived, and a leading fire fighter said, "It was fortunate that potassium wasn't involved as it would have reacted more violently and exploded. These Group 1 *alkali metals* can be very dangerous".

- (a) Group 1 metals are stored under oil.

Suggest why.

acts as barrier between sodium and air / oxygen / water (vapour)

(b) Describe **one** piece of evidence to support the Law of

(b) eg link between Li, Na, K, (Rb, Cs)

or Mg, Ca, (Sr, Ba)

or F, Cl, Br, I

*allow any **two** elements in the same group (in both Newland's **and** the modern periodic table)*

1

linked appropriate comment about that link eg similar physical / chemical properties **or** similar specific reactions **or** same number of outer electrons

*if no elements identified, allow **1** mark for a general comment about elements **in the same column** having similar properties*

*“every eighth element has similar properties” = **1** mark*

1

(c) any **two** from:

- no gaps for undiscovered elements **or** elements still being discovered
- some boxes have 2 elements
- metals and non-metals in same column / mixed up / some elements in the same column had different properties
- pattern for first 16 or so elements only
- any sensible suggestion about misplaced elements eg copper in group 1 metals

2

- (a) Mendeleev's periodic table was produced without any knowledge of the atomic structure of elements.

State why Mendeleev left gaps in his periodic table.

(a) for undiscovered elements

1

(b) because the elements are in order of number of electrons or proton number

1

- (b) The modern periodic table is based on the atomic structure of elements.

because the number of energy levels / shells is the number of the period

1

The modern periodic table is based on the atomic structure of elements in terms of the number of protons and electrons.

because the number of electrons in the outer energy level / shell is the number of the group, except in the case of the noble gases

1

Explain how.

[4]

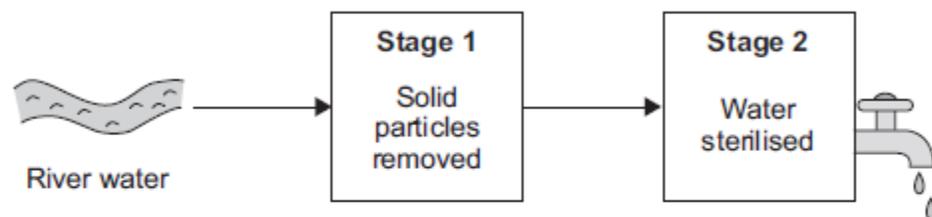
C3 chapter 2: water

1. Hard water contains magnesium ions and calcium ions. With soap hard water produces a scum, while with soft you
 2. Soft water? Which type of water
 3. Why is it called hard water?
 4. What are the disadvantages of it?
 5. Evaluate the advantages and disadvantages of hard water.
 6. What happens when hard water is boiled?
 7. How is limescale removed from a kettle's heating element?
 8. Describe what the ion-exchange process is.
 9. What should drinking water contain?
 10. How are solids removed from water?
 11. What do water filters do?
 12. Why is fluoride added to drinking water?
5. Advantages: Ca^{2+} ions are good for healthy teeth and bones. Less risk of developing heart disease due to more minerals. Disadvantages: Produces scum when mixed with soap. Forms scale when heated which affects the efficiency of heating systems.
7. When boiled, the calcium hydrogencarbonate decomposes to form calcium carbonate which is insoluble – the limescale on a kettle's heating element.
8. Columns which water is run through that contain many sodium or hydrogen ions. These ions are exchanged for the calcium and magnesium ions.
10. Solids are removed by filtering water through a mesh screen. Smaller solids are then stuck together by chemicals so they fall to the bottom to be filtered out again through gravel.
11. Ensure that water is safe to drink by removing solids and harmful microbes.
12. To reduce tooth decay.

This question is about water.

River water needs to be treated before it is safe to drink.

(a) The diagram shows two stages of the treatment of river water.



(i) What is the name of the process used to remove solid particles in **Stage 1**?

Tick (✓) **one** box.

Crystallisation

Fermentation

(a) (i) Filtration

(ii) What is added in **Stage 2** to sterilise the water?

Tick (✓) **one** box.

(ii) Chlorine

Fluoride

Potassium

(1)

(1)

(b) Toxic substances in river water are removed by adding very small amounts of iron oxide nanoparticles.

(i) How is the size of nanoparticles different from normal-sized particles?

(b) (i) nanoparticles are small / smaller / much smaller / tiny

allow any in range 1–100 nm or $1 \times 10^{-9} \text{ m} - 1 \times 10^{-7} \text{ m}$ or a few hundred atoms in size

ignore numbers if stated smaller

1

(1)

(ii) Nanoparticles are needed in only very small amounts.

(ii) they have a high surface area to volume ratio

reference to surface area without volume ratio is insufficient

allow nanoparticles are very reactive or nanoparticles are more reactive than normal particles.

1

(1)

(c) In certain areas of the UK, tap water contains aluminium ions.

What would you **see** when sodium hydroxide solution is added drop by drop to tap water containing aluminium ions?

(c) (sodium hydroxide) produces a white precipitate

accept solid / suspension or ppt or ppte for precipitate.

ignore cloudy / milky

1

which (then) dissolves / disappears (in excess sodium hydroxide)

M2 cannot be awarded unless a solid of some sort has been made

ignore names or formulae of compounds

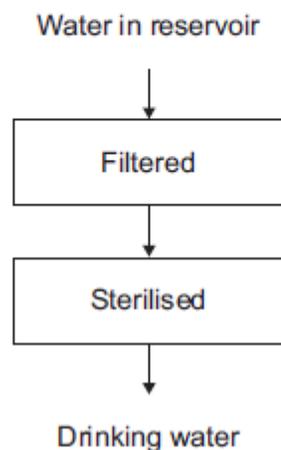
1

(2)

6 marks)

This question is about drinking water.

(a) The flow diagram below shows how water is made suitable for drinking.



(i) What is removed when the water is filtered?

Tick (✓) **one** box.

Gases

Liquids

(a) (i) Solids

(1)

(ii) What is used to sterilise the water?

Tick (✓) **one** box.

Carbon

(ii) Chlorine

Sodium chloride

(1)

(iii) Why is the water sterilised?

(iii) kill microbes / bacteria

allow to make the water safe to drink

ignore disinfect

ignore remove / get rid of microbes

(b) Water can be purified by distillation.

Drinking water is **not** usually purified by distillation because distillation is expensive.

Complete the sentence.

Distillation is expensive because it requires a lot of

energy

allow heat

(1)

(c) Why do some water companies add fluoride to drinking water?

improve dental health

allow reduce tooth decay

allow (local) government requirement

allow help teeth

(1)

(Total 5 marks)

This question is about water.

(a) Rainwater is soft.

How is hard water produced from rainwater?

(calcium or magnesium) ions causing water hardness are dissolved

ignore named anions

1

from rocks

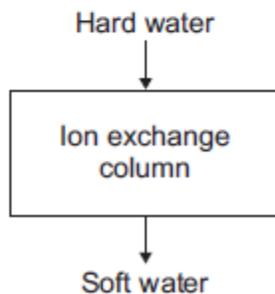
allow limestone

1

(b) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Hard water can be softened by two different methods.

Method 1: Ion exchange



Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a 'best-fit' approach to the marking.

0 marks

No relevant content

Level 1 (1–2 marks)

There is a statement about one of the methods **or** one advantage of one of the methods

Level 2 (3–4 marks)

There is a description of one method of water softening **and** one advantage of a method is given

Level 3 (5–6 marks)

There is a description of both methods of water softening **and** a comparison of the two methods by giving an advantage of at least one of them

general:

- hard water contains calcium / magnesium (ions)
- softening water involves removal of calcium / magnesium (ions).

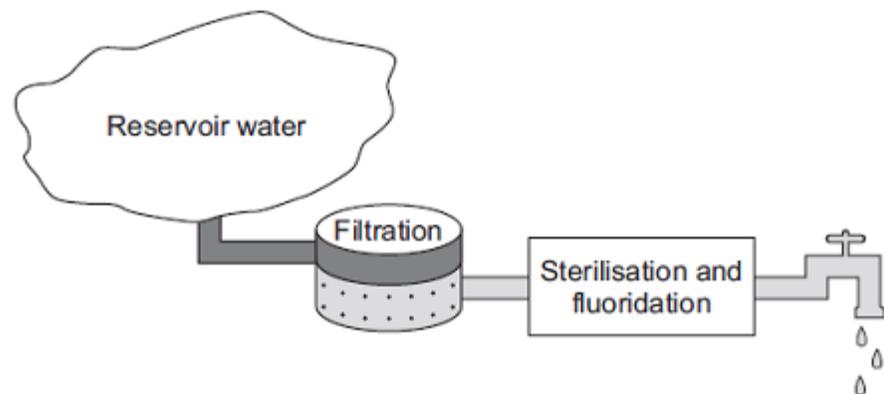
ion exchange:

- resin
- contains sodium / hydrogen ions
- which are exchanged with calcium / magnesium ions
- resin needs periodic replenishment with sodium ions / hydrogen ions or sodium chloride (disadvantage).
- increases sodium content of water (if sodium ions used) (disadvantage)
- easy / quick method to use (advantage)
- continuous process (advantage).

sodium carbonate:

- sodium carbonate is added to hard water
- calcium / magnesium ions precipitate out
- as calcium / magnesium carbonate
- batch process (disadvantage)
- leaves a residue of precipitated carbonate in the water (disadvantage)
- increases sodium content of water (disadvantage)
- easy method to use (advantage)
- relatively cheap (advantage).

The diagram shows three stages in the treatment of reservoir water.



(a) (i) What is separated from the reservoir water during filtration?

Tick (✓) **one** box.

Bacteria

Dissolved nitrates

Solids

(ii) What is added to sterilise the water?

Tick (✓) **one** box.

Calcium

Chlorine

Magnesium

(iii) State **one** advantage of adding fluoride to drinking water.

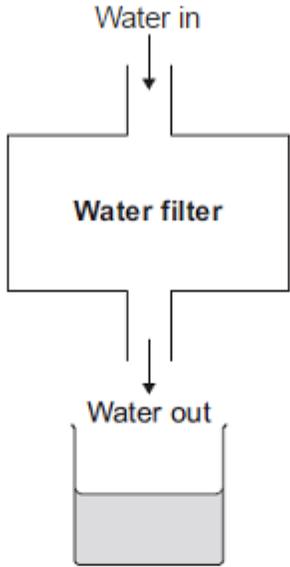
improves dental health **or** reduces tooth decay

(1)

(1)

(1)

(b) The diagram shows a water filter used in the home.



A student collected a sample of water from the filter.

The student could show that the filtered water contains dissolved salts without using a chemical test.

Describe how.

put a sample of the filtered water in an evaporating basin **or** leave to evaporate
accept any description of evaporation (using a Bunsen or leaving on the windowsill)

there will be crystals of salt left

.....

.....

(c) Seawater contains dissolved sodium chloride.

(i) Describe a test that could be used to show the presence of sodium ions in seawater.

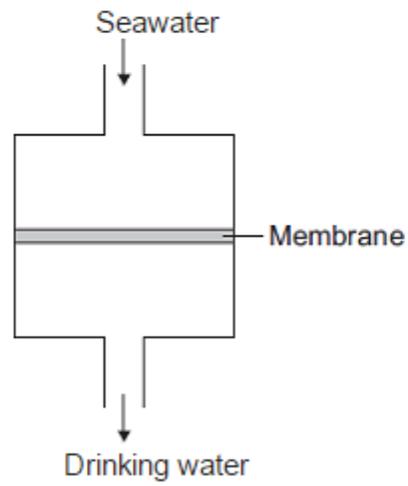
Test – flame test 1

Result – yellow / orange / persistent orange flame 1

.....

(2)

(ii) Seawater is forced through a membrane to make drinking water.



Suggest why water molecules can pass through the membrane, but sodium ions and chloride ions cannot.

sodium and / or chloride ions are bigger than water (molecules) **or** ions are charged **or** molecules are not charged

do not accept sodium chloride molecules as ions is given in the question

(2)

(1)

Hard water causes scale to form in kettles, as shown in the figure below.



© Steve Gorton/Thinkstock

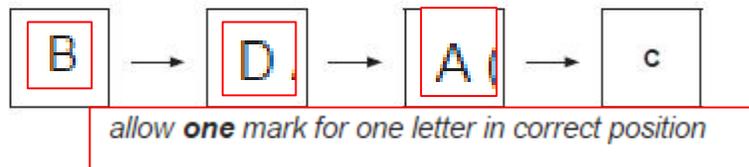
(a) The sentences describe how water becomes hard and causes scale.

The sentences are in the wrong order.

- A Water is heated.
- B Water flows over rocks.
- C Scale forms.
- D Ions causing hardness dissolve in the water.

Complete the boxes to show the correct order of the sentences.

The last box has been done for you.



(b) Draw a ring around the correct answer to complete the sentence.

Hardness in water is caused by dissolved

calcium ions

chloride ions.

sodium ions.

(1)

(c) Vinegar is used to remove scale in kettles.

Vinegar contains the acid with the formula CH_3COOH

(i) Draw a ring around the correct answer to complete the sentence.

Vinegar contains

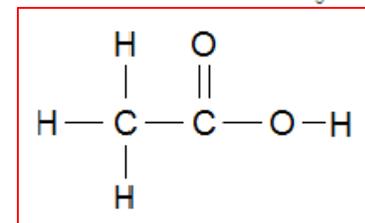
ethanoic acid

nitric acid.

sulfuric acid.

(1)

(ii) Complete the displayed structure of the acid CH_3COOH



(1)

(iii) Scale in kettles contains calcium carbonate.

When vinegar reacts with scale, a gas is produced.

Name the gas.

carbon dioxide
allow CO_2

(1)

(d) Why does removing the scale from a kettle save money?

more efficient heating
allow saves energy
allow takes less time to boil

(1)

(e) Hard water reacts with soap.

Complete the sentence.

When hard water reacts with soap, it forms

scum

accept calcium stearate
accept magnesium stearate
accept (white) precipitate

(1)

Water in Britain is taken from reservoirs to use as drinking water.



© KatieJonesPhotography/iStock/Thinkstock

(a) What are the **two** main steps used to treat water from reservoirs?

Give **one** reason for each step.

filter	1
to remove <u>solids</u> or insoluble particles	
OR	
add coagulant (1)	
flocculation / settling / remove solids (1)	1
(add) chlorine	
accept ozone / UV	1
to reduce the number of microbes	
accept to kill microbes / bacteria / germs	
accept sterilise	
allow disinfect	
ignore remove microbes	

(b) Some people use water filters to treat water before drinking it.

(i) Water filters remove hardness from hard water.

What is in water filters that removes hardness from water?

ion exchange resin
allow ion exchange column
allow sodium ions / Na^+
allow hydrogen ions / H^+

(1)

(ii) Suggest why water filters used in the home contain particles of silver.

prevent growth of microbes
accept sterilise
accept to kill microbes / bacteria / germs
accept to reduce the number of microbes
ignore remove microbes

(1)

(c) Pure water can be produced by distillation.

Why is distillation **not** usually an economic method of treating water for drinking?

high cost of energy / heating
allow uses a lot of energy

(1)

(d) Drinking hard water has health benefits.

State **one** health benefit of drinking hard water.

any **one** from:

- helps to develop / maintain bones
allow any suitable positive effect on bones
- helps to develop / maintain teeth
allow any suitable positive effect on teeth
- reduces heart disease

(1)

(4)

Most water contains dissolved compounds.

The concentrations of these dissolved compounds are higher in sea water than in drinking water

(a) (i) Draw a ring around the correct answer to complete the sentence.

Pure water can be obtained from sea water by

- distillation
- filtration.
- neutralisation.

(ii) What is the boiling point of pure water? 100 °C

(b) A student wanted to find out how much solid was dissolved in sea water.

This is the method the student used:

- measure the mass of an empty evaporating basin
- measure 25 cm³ of sea water and pour it into the evaporating basin
- heat the evaporating basin gently until all of the water has evaporated
- measure the mass of the evaporating basin containing the solid residue.

(i) What piece of apparatus would be suitable for measuring 25 cm³ of sea water?

measuring cylinder **or** pipette **or** burette
allow phonetic spelling

*do **not** accept teat pipette*
ignore any additional words or volumes

(1)

(ii) How could the student check that all of the water had evaporated?

(re)heat the evaporating basin
accept heat to constant mass for 2 marks

1

weigh (again) **or** mass will not change

if no other mark awarded allow 1 mark for a chemical test for water

1

(2)

(iii) The results the student obtained using 25 cm³ of sea water are:

mass of empty evaporating basin = 23.21 g

mass of evaporating basin and dry solid residue = 24.04 g

Calculate the mass of solid dissolved in 1000 cm³ of the sea water.

.....
.....
33.2 (g)

correct answer with or without working scores 2 marks

allow mass of residue = (24.04 g - 23.21 g) = 0.83 for 1 mark

allow ecf (mass of residue × 40) for 1 mark

(2)

(c) In many countries chlorine is added to drinking water supplies.

Why is chlorine added to drinking water?

.....
to kill microbes / bacteria **or** to sterilise / disinfect water

allow to prevent disease

ignore 'to make it safe to drink'

(1)

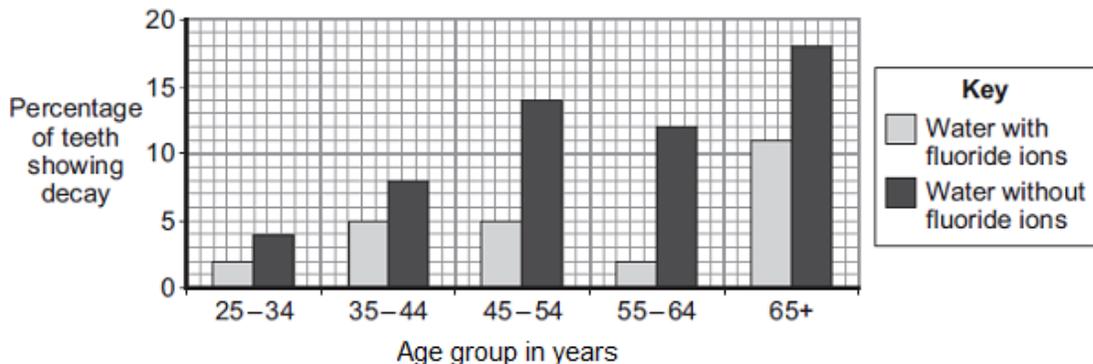
(d) In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

Compounds containing fluoride ions are added to some drinking water supplies.

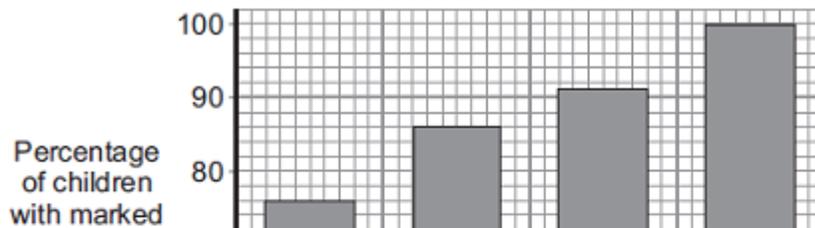
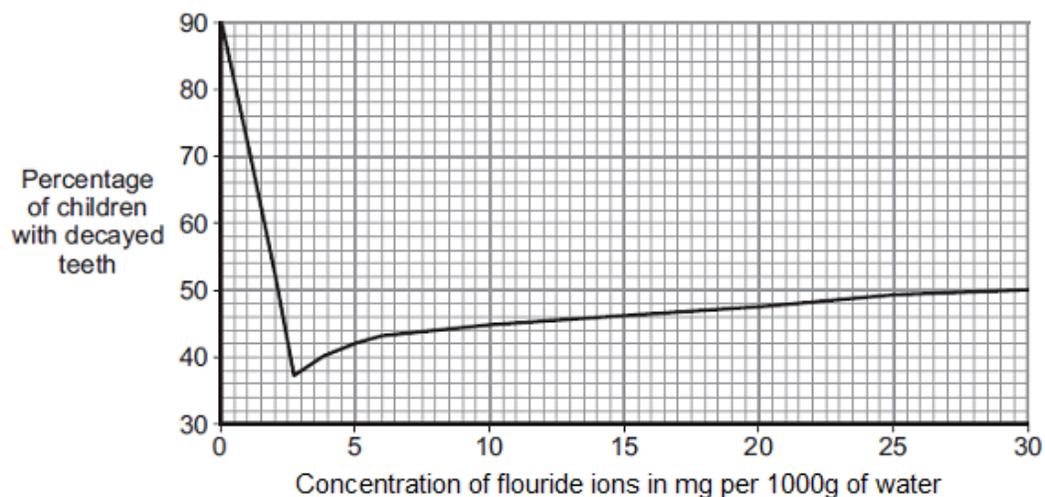
Many scientists have done research into the effects of fluoride ions in drinking water.

Graphs 1, 2 and 3 show some of the results obtained.

Graph 1



Graph 2



Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response. Examiners should also refer to the information on page 4, and apply a 'best-fit' approach to the marking.

0 marks

No relevant content

Level 1 (1 – 2 marks)

A simple relevant comment has been made on the data from at least one of the graphs.

Level 2 (3 – 4 marks)

At least two of the graphs have been considered with a relevant comment made.

Level 3 (5 – 6 marks)

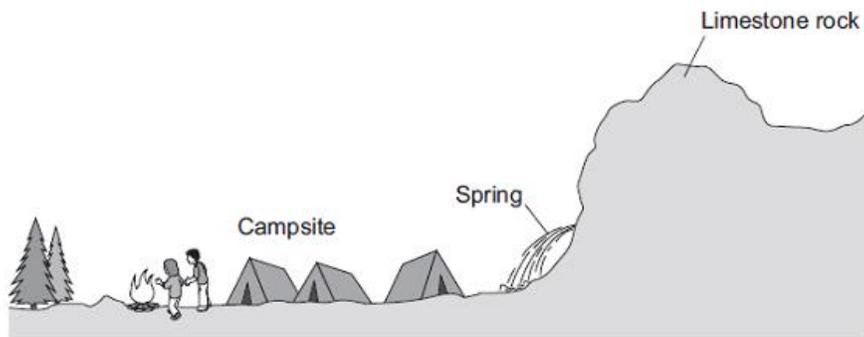
All the graphs have been considered and relevant comments made about each. A justified conclusion may be given.

examples of chemistry points made in the response:

extra information

- (graph 1 shows) fluoride ions reduce the amount of tooth decay
- (graph 1 shows) the effect in reducing tooth decay is greatest for 55–64 year olds
accept any in range 55 – 64
- (graph 2 shows) the fluoride ions reduce percentage with decayed teeth
- (graph 2 shows) effect is greatest at 2.5 to 3 mg per 1000 g of water then decay increases if more than 2.5 to 3 mg of fluoride ions per 1000 g water
accept any in range 2.5 – 3
- (graph 2 shows percentage) decay decreases from 90 to 38 mg per 1000 g
- (graph 3 shows) more marked / brittle teeth as fluoride level increases
- above points linked together to draw a justified conclusion

This question is about hard water.



(a) A campsite has a spring, where water flows out of limestone rock.

(i) The water from the spring is hard because it contains calcium ions.

How do the calcium ions get into the spring water?

limestone dissolves
 accept rock dissolves
 allow references to the process e.g. hydrogencarbonate ion formation

(ii) A student at the campsite boils some of the spring water in a pan. The inside of the pan becomes coated with a white solid.

What is the white solid?

calcium carbonate
 accept (lime)scale
 ignore limestone
 do **not** accept scum

(iii) When the student uses soap to wash in the spring water, scum forms. Scum is **not** formed if the spring water has been boiled and allowed to cool.

Draw a ring around the correct answer to complete the sentence.

The hardness in the spring water is

acidic.
 permanent
temporary

(1)

(1)

(1)

(b) In a laboratory, a student compared the hardness of three different samples of water.

The student measured 20 cm³ of water into a boiling tube.

The student then:

- added a drop of soap solution
- shook the boiling tube for 10 seconds
- looked to see if a permanent lather had formed.

The student repeated the procedure until a permanent lather formed.

The results are shown in the table.

Water sample	Number of drops of soap solution needed to form a permanent lather			
	Test 1	Test 2	Test 3	Mean
Spring water	13	11	6	
Tap water	7	5	6	6
Distilled water	1	1	1	1

(i) Calculate the correct mean for spring water.

..... 12
 correct answer with or without working = 2 marks
 evidence of (13 + 11)/2 gains 1
 allow 10 for 1 mark

(2)

(ii) Which of the three sources of water was hardest?

Draw a ring round the correct answer.

distilled water

spring water

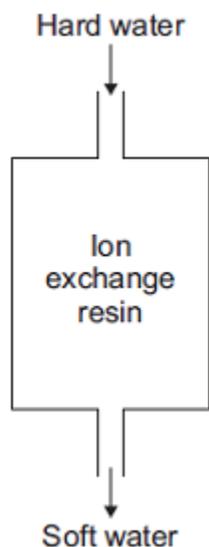
tap water

Use the results in the table to give a reason for your answer.

..... most soap (solution) needed
 depends on first marking point
 comparison required
 allow highest number of drops

(2)

(c) Ion exchange columns are used to soften hard water.



(i) Draw a ring around the correct answer to complete each sentence.

The ion exchange column softens water by dissolving
evaporating
removing calcium ions.

Calcium ions in the water exchange with chloride
magnesium
sodium ions in the column.

(ii) After a few weeks sodium chloride solution needs to be passed through the ion exchange column.

Suggest why.

to replenish sodium (ions in resin)
accept Na^+
allow 'so sodium ions do not run out'
allow 'to remove calcium / magnesium ions'

(1)

(c) Tap water in the UK is safe to drink because water companies add chlorine to sterilise the water.

Suggest **one** argument for and **one** argument against water companies adding chlorine to sterilise water.

Argument for:

any **one** from:

- prevents disease
ignore sterilise / disinfect
allow prevents illness
- kills microbes / microorganisms / bacteria / pathogens
ignore removes
- only small amounts needed

1

(2)

Argument against:

any **one** from:

- ignore cost / taste / corrosive*
- toxic / poisonous
ignore harmful or causes health problems or specific illnesses / diseases
- no consumer choice
allow unethical

1

Good quality water is essential for life.

(a) In the United Kingdom, water is filtered and treated with chlorine to make it safe to drink.



Explain why the water is:

filtered

removes insoluble / solid
Ignore named substances / minerals
 do **not** accept ions

treated with chlorine

kills microorganisms / microbes / bacteria / disinfects (water)
allow kills germs / pathogens or sterilises
allow chlorine is a disinfectant
ignore cleans water or removes impurities / bacteria

(b) Millions of people in Bangladesh drink water from wells that contain high levels of arsenic. Arsenic is poisonous.

The World Health Organisation recommends that there should be no more than 0.01 mg of arsenic per litre in drinking water.

The table gives some information about two instrumental methods of testing for arsenic.

Factor to consider	Laboratory Instrumental Method	Portable Instrumental Method
Cost of equipment	£10 000	£50
Skill level of technician	Highly skilled	where test is done
Little training needed	Laboratory only	Anywhere
Time to prepare the instrument for the test	5 minutes	10 seconds
Sensitivity of the instrument	0.000001 mg of arsenic per litre of water	0.1 mg of arsenic per litre of water

(i) Use the information in the table to give **two** advantages and **one** disadvantage of using the Portable Instrumental Method compared with the Laboratory Instrumental Method.

advantages of portable:

accept converse throughout

any **two** from :

- costs less
- little training needed
- water can be tested within 10 seconds / immediately / quicker
- can be used anywhere

2

disadvantage of portable

less precise / sensitive

allow only detect down to 0.1 mg

ignore less accurate

1

(3)

(ii) The information about these two instrumental methods was provided by the Professional Institute of Water Engineers (PIWE). The Institute has no connection with the companies that make these instruments.

Suggest why many people would accept the views of PIWE rather than the views of the companies that make the instruments.

(ii) (PIWE) is unbiased

it / they = PIWE

allow honest / trusted / respected / reliable

ignore professional / scientific / skilled

or

company may be biased

allow company trying to sell products

1

(1)

These labels have been taken from two bottles of spring water.

Mountain View

Natural Spring Water

*Contains essential minerals
for good health*

Analysis

Ions present	mg/dm ³
Calcium	65
Magnesium	35
Potassium	5
Sodium	12
Chloride	9
Hydrogencarbonate	269
Sulfate	21

Also tested by the independent Food Standards Agency and approved safe.

Valley Croft

Pure Spring Water

**With healthy minerals
as Nature intended**

Analysis

Ions present	mg/dm ³
Calcium	16
Magnesium	14
Potassium	5
Sodium	34
Chloride	13
Hydrogencarbonate	62
Sulfate	7

Pure and natural – contains no chemicals.

Tested in our own laboratories by our own scientists to keep you safe.

(a) Mountain View and Valley Croft spring waters are hard because they contain calcium and magnesium ions.

(i) Mountain View spring water is about **three** times as hard as Valley Croft spring water.

Use the information on the labels to explain why.

Mountain View: $(65+35 =)100$

Valley Croft: $(16+14 =) 30$

OR

Mountain View Ca (65) is about 4 times Valley Croft (Ca 16) (1)

Mountain View Mg (35) is about twice Valley Croft (Mg 14) (1)

*ignore other ions unless used in another calculation or calculations.
In this case the list principle applies*

if no other mark awarded either:

*Ca 65 compared with Ca 16 **and** Mg 35 compared with Mg 14 gains
1 mark*

or

*difference in Ca $(65 - 16) = 49$ **and** Mg $(35 - 14) = 21$ gains 1 mark*

(2)

(ii) Describe how a student could use soap solution to show that Mountain View spring water is about **three** times as hard as Valley Croft spring water.

You should state how the experiment is made fair and give the expected result.

shake / stir / swirl (water with soap)

allow mix

ignore add / use soap / titrate

1

(about) 3 × the scum / precipitate / solid (compared with Valley Croft)

*accept (about) 3 × volume / drops / amount / quantity of soap
solution for (permanent) lather (compared with Valley Croft)*

ignore scale / time

1

(3)

fair test: eg same volume / amount of water **or** shake for same amount of time **or** use same type / concentration of soap

allow same temperature

*do **not** accept same volume of soap*

ignore repeat the experiment

1

These labels have been taken from two bottles of spring water.

Mountain View

Natural Spring Water

Contains essential minerals
for good health

Analysis

Ions present	mg/dm ³
Calcium	65
Magnesium	35
Potassium	5
Sodium	12
Chloride	9
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Chloride	13
Hydrogencarbonate	62
Sulfate	7

Pure and natural – contains no chemicals.

Tested in our own laboratories by
our own scientists to keep you safe.

(b) Why is hard water good for health?

strong(er) teeth / bones

allow contains calcium (ions / compounds)

or

good for heart

*ignore magnesium **or** charge on the calcium ion
do **not** accept any other ions*

(c) Give **one** disadvantage of hard water.

any **one** from:

ignore health effects

- produces scale / limescale / calcium carbonate / magnesium carbonate
allow fur for scale
- produces scum
- more soap needed
*allow doesn't lather easily
ignore detergent*
- costs more to soften water
allow costs if qualified
- (scale) lowers efficiency of appliances
ignore just damage to pipes

(1)

(d) (i) Suggest why people should be concerned about the claim that Valley Croft spring water "contains no chemicals".

- (i) water / everything is made of / contains chemicals
or water contains named ion from the label

*accept company (probably) means water contains no added
substances*

ignore water has not been treated

1

(1)

(ii) Suggest why people should be concerned that Valley Croft spring water has only been tested by their own scientists.

- (ii) Valley Croft scientists may be biased / vested interest

*accept Food Standards Agency / independent scientists (more likely
to be) unbiased*

*allow Valley Croft scientists may falsify results
ignore accuracy / reliability / fairness / validity*

1

(1)

Chlorine is used to make bleaches, plastics and medicines.
Swimming pool water is often treated with chlorine.

Chlorine is used to make water safe to drink. It is relatively cheap and easy to use. People who drink untreated water risk dying from typhoid and cholera.

However, chlorine has some difficulties and can be harmful to the environment.
Chlorine is used to make water safe to drink. It is relatively cheap and easy to use. People who drink untreated water risk dying from typhoid and cholera.

(a) How does chlorine make water safe to drink?

(a) sterilise / disinfect (water)

ignore removes bacteria / impurities / disease

or

kill bacteria / micro-organisms / microbes / germs / pathogens

ignore cleans the water / makes (water) safe

allow destroy bacteria or gets rid of bacteria

Some people use water filters because they are concerned about the quality of drinking water.

(a) Draw a ring around the correct answer to complete each sentence.

(i) One of the active chemicals in many water filters is

- carbon.
- magnesium.
- sulfur.

(ii) In many areas of the United Kingdom the water is hard.

The hardness in water is caused by

- bromide
 - calcium
 - hydrogen
- ions.

(b) Describe and give the result of a test to show that some drinking water is hard.

Test

(c) State and explain **one** benefit of drinking hard water.

.....

.....

.....

.....

(2)

(b) (shake with) soap (solution)

ignore detergent

scum

accept less lather with hard water

allow solid / precipitate

ignore bubbles

incorrect test = 0 marks for question

correct results with no test score 1

(c) any **two** from:

- good for health / healthier
ignore vitamins
- stronger bones / teeth
- less heart disease

In the United Kingdom, water companies supply drinking water to our homes. However, some people are concerned about the taste and quality of the water that is supplied.

Describe one method that people use to improve the taste and quality of the tap water supplied to their homes. How the method works.

.....

.....

.....

.....

.....

.....

.....

use of (water) filters / ion exchange	1
filters containing carbon / charcoal / silver / resins <i>ignore other substances</i>	1
any two from:	
• carbon / charcoal removes chlorine	
• carbon / charcoal removes soluble / dissolved substances	
• silver kills / prevents growth of microorganisms	
• ion exchange removes calcium ions / magnesium ions / metal ions	
• ion exchange replaces (metal ions) with H ⁺ / Na ⁺ <i>allow exchange for replace</i>	

(a) Describe and explain how ions get into these samples of water.

(a) contact with rocks

1

(ions) dissolve / soluble / react

allow water is a solvent

ignore 'picks up' / 'gets into' /

absorbed

1

(2)

-
- (a) Water in some parts of the UK is hard, but in other parts of the UK it is soft.

Draw a ring around the correct answer to complete each sentence.

- (i) Water becomes hard because ions in rocks

condense	
dissolve	← into the water
evaporate	

(1)

- (ii) Hardness in water is caused by

calcium	←	
hydrogen		ions
sodium		

Statement

Type of water

Easily makes a lather with soap

Permanent hard water

Can be made soft by boiling

Temporary hard water

Soft water

(2)

(c) Water of the correct quality is essential for life.

In many parts of the world the water used for drinking contains solid particles and harmful bacteria.

Suggest **two** methods that could be used to improve the quality of this water.

1	(c) filter	1
2	add chlorine	
	<i>accept sterilise</i>	1	(2)

(i) Explain how scale forms on heating elements.

(a) (i) on heating, the calcium hydrogencarbonate decomposes

1

forming a scale of insoluble calcium carbonate

1

(2)

(ii) Suggest why scale on heating elements causes problems.

(ii) the scale reduces the efficiency of the heating element or the scale increases energy costs / uses more energy

1

(1)

(ii) Explain how a water filter containing carbon, silver and ion exchange resin softens permanent hard water.

(ii) sodium / hydrogen ions are present in the ion exchange resin

1

therefore the water is softened because these ions take the place of calcium / magnesium ions that cause hardness in the water

1

(2)

- (a) In some parts of the world the water is hard, but in other parts the water is soft.

Draw a ring around the correct answer to complete these sentences.

(i)

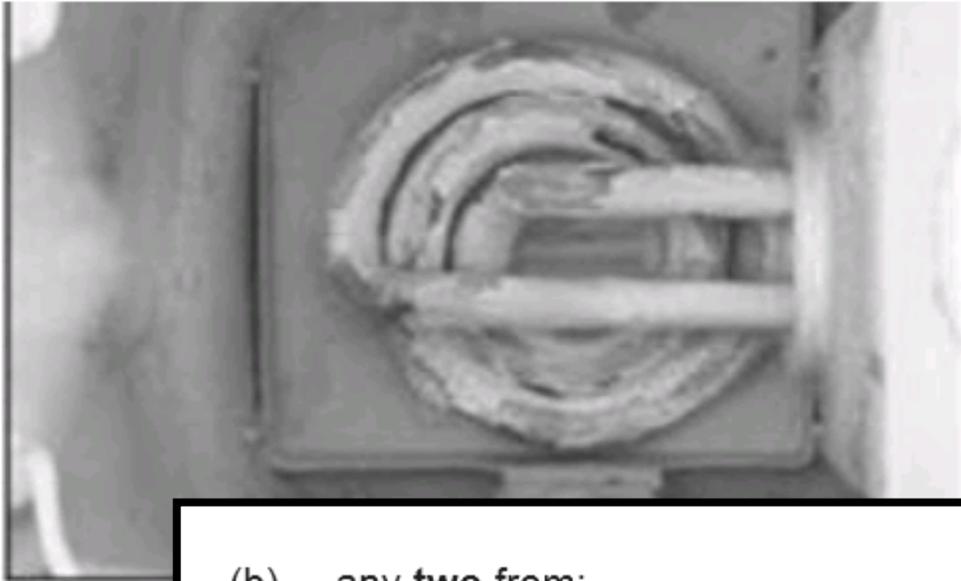
	condense	
When water comes into contact with rocks, ions	dissolve	into the water.
	evaporate	

(1)

(iv) The ions that cause hardness are removed by adding a substance

	neutralises	
which	oxidises	them.
	precipitates	←

(1)



Explain

(b) any **two** from:

- (lime)scale
accept precipitate
ignore scum
- acts as insulator / covers element / prevents heat passing through
- requires more energy
ignore references to time

2

(2)

In some parts of the world the water is hard, but in other parts the water is soft.

(i) Name an ion that causes water to be hard.

(i) calcium (ion) / Ca^{2+}

ignore any formula

if ion only must be correct

accept magnesium (ion) / Mg^{2+}

do not accept named compounds

1

(1)

(ii)

(ii) contact with rocks

accept named rocks

*ignore ground / deposits / soil /
minerals / ores*

1

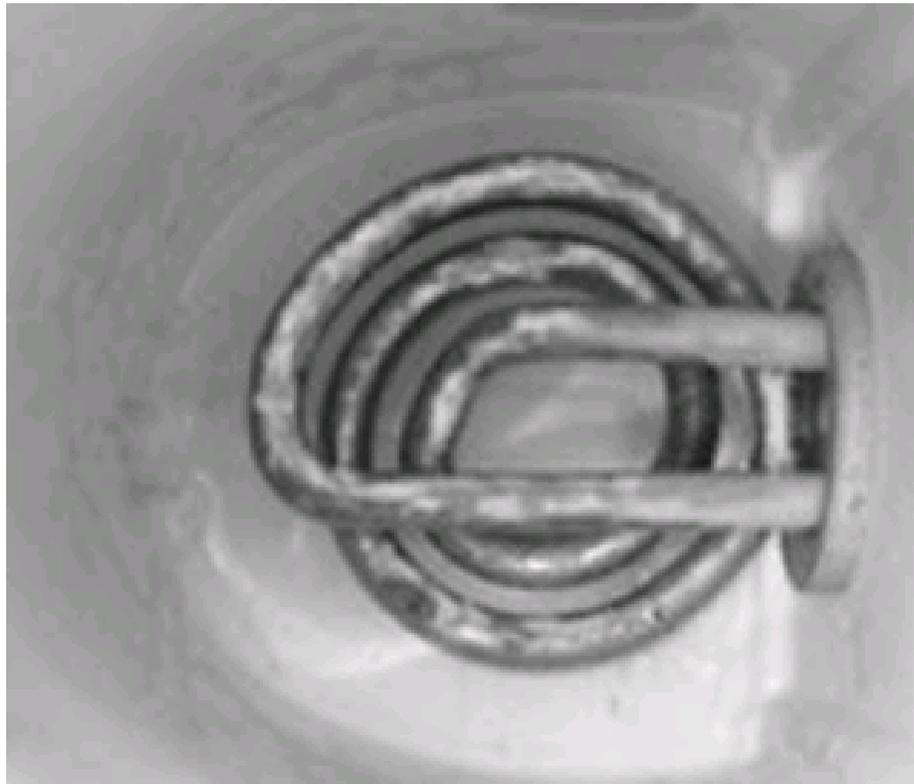
(ions / substances) dissolved / soluble / leached / reacts

*ignore erode / corrode / picks up /
absorb*

1

(2)

Two problems of hard water are *scale* and *scum*, as shown in the pictures of a heating element and a wash basin.



(a) scale – (solid) formed when heat decomposes dissolved calcium / magnesium compounds owtte

allow: scale is formed when hard water is heated / boiled (to leave magnesium / calcium compounds)

scale is calcium carbonate / CaCO_3 or magnesium carbonate / MgCO_3

ignore evaporate

1

scum – (ppt) formed when soap reacts with calcium / magnesium (ions) owtte

allow scum is formed when hard water reacts with soap

scum is calcium stearate / magnesium stearate

1

(a) Explain the difference between

method 1:

filter

ignore screening / sedimentation

explanation 1:

remove insoluble substances / remove solids / small bits / dirt / mud/ soil / sand / silt

method 2:

precipitate / flocculate / add eg. alum

allow other named substances

explanation 2:

method 3:

add chlorine / chlorine dioxide / ozone

explanation 3:

sterilise / kill bacteria / microorganisms / microbes

ignore 'remove bacteria'

ignore disinfect

s (some) metal

.....

.....

.....

(Total 3 marks)

(a)

(a) perfume

1

(b) a substance that whitens / removes colour or stains allow
kills bacteria / germs

1)

not 'cleans'

(b)

1

(c) (i) does not form a lather (with soap)

accept 'forms scum with soap'

1)

(c)

or contains calcium sulphate / calcium hydrogen
carbonate / soluble

magnesium salt / Ca^{2+} / Mg^{2+}

1

(ii) no scum formed / soap more effective / save money on
soap / furs

up pipes etc / limescale deposits

not 'to get lather'

1)

1

(a) Name the compound that would be present in the greatest amount in water that is hard to dryness.

(a) calcium

allow formulae

1

carbonate

1

(b) (i) soap

allow 2 marks for

"contains CaSO_4 / $\text{Ca}(\text{HCO}_3)_2$ / Ca^{2+} / Mg^{2+} "

1

forms scum / no bubbles / no lather

*allow 1 mark for "contains Ca / Mg"
do not allow "contains CaCO_3 "*

1

(ii) taste / strengthen bones, teeth etc / health reason e.g. less heart disease / makes better beer

1

(c) (shake with) soap; makes scum / no lather

1

boil (a fresh sample)

1

retest with soap

1

result/comparison

alternative answers:

boil (not to dryness)

cloudiness in water/some deposit formed

if a comparison is made with a sample of a soft water, a further 2 marks would be possible

1

(c) Describe an experiment that would show that this water is temporarily hard.

HOW HARD WATER COSTS YOU HARD CASH

Hard water causes:

- B lower water heating costs 1
- S reduce soap used / no scum
- T *not no blocked showers* 1
- E less maintenance / use of plumber / don't need to buy new heater or shower / no descaling needed (pipes or showers) / no cleaning of blocked pipes 1

Describe

[3]

(Total 3 marks)

(c) What would be the effect of using **temporarily** hard water in a kettle?

(c) build up of fur / scale / forms CaCO_3 / precipitate formed
not 'scum'

wastes energy / less efficient / takes longer to boil

1

(d) (i) sample B

1

contains (calcium) sulphate / SO_4^{2-}

1

(d) (i) Explain

not softened by boiling / does not contain many HCO_3^- ions / cannot precipitate CaCO_3

1

(2)

acidic	alkaline
	dissolves
hard	reacts

You may use

Rainwater is
with limestone

solution form

(a)	acidic	1
	reacts	1
	hard	1
	tastes	1

One advantage of

drinking the water from the lake is that it better than rainwater.

3. Energy Calculations

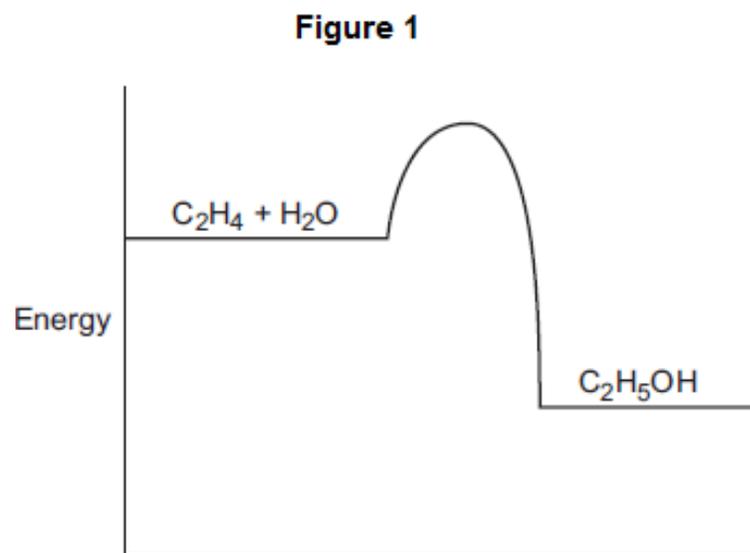
<ol style="list-style-type: none"> 1. What is the biggest error in energy measurements? 2. Describe an experiment that would measure the amount of energy released in a reaction in a polystyrene cup. 3. What is an exothermic reaction? Give an example. 4. What is an endothermic reaction? Give an example. 5. What is meant by bond energy? 6. What happens when bonds are broken? 7. Is bond breaking endothermic or exothermic? 8. Is bond forming endothermic or exothermic? 9. How would you calculate if an experiment is endothermic or exothermic? 	<ol style="list-style-type: none"> 1. The amount of energy needed to break the bonds in the reactants. 2. Take the temperature of the solutions before the reaction. 3. One that gives out energy to the surroundings. 4. One that takes in energy from the surroundings, usually in the form of heat. 5. The amount of energy needed to break the bonds in the reactants. 6. Energy is taken in. 11. -Put set amount of water in copper can and record its temperature. -Weigh spirit burner and lid. -Put the spirit burner underneath the can. 	<p>g a</p>
<p>12. Energy transferred (joules) = mass of water (grams) x specific heat capacity (J/g°C)</p> <ol style="list-style-type: none"> 12. What is the equation for energy transfer? 13. Name three disadvantages of burning fossil fuels for energy. 14. What does activation energy mean? 15. How does a catalyst affect the activation energy? 16. What type of reaction occurs between oxygen and hydrogen? 17. Name an advantage of using hydrogen as a fuel. 18. Name two disadvantages of using hydrogen as a fuel. 19. What is a fuel cell? 20. What would be an advantage of using fuel cells in vehicles? 	<ol style="list-style-type: none"> 13. -They are finite. -They produce greenhouse gases (like carbon dioxide) which contribute to global warming. 14. The minimum energy needed by a reaction to get started. 15. They lower them. 19. A fuel cell is an electrical cell that is able to convert the chemical energy of a fuel into electricity. 20. They can replace petrol and diesel engines and they don't produce any harmful products. 	<p>(°C)</p>

This question is about ethanol.

(a) Ethanol is produced by the reaction of ethene and steam:



(i) **Figure 1** shows the energy level diagram for the reaction.



How does the energy level diagram show that the reaction is exothermic?

- (a) (i) the products are at a lower energy level than the reactants
accept products have less energy / less energy at the end than the beginning

1

(1)

(ii) A catalyst is used for the reaction.

Explain how a catalyst increases the rate of the reaction.

- (ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route

accept adsorption or 'increases concentration at the surface'

ignore absorption

1

(that has) lower activation energy

allow weakens bonds

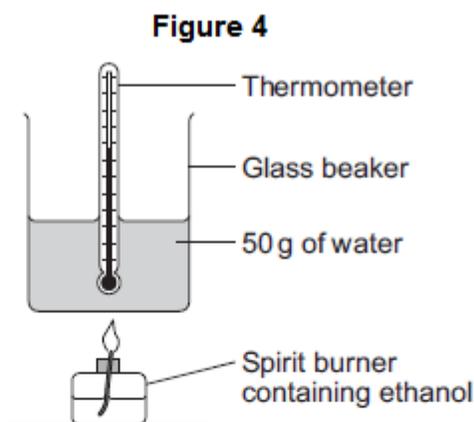
allow idea of increased successful collisions.

DO NOT ALLOW answers stating catalysts provide energy for M1 and M2

1

(c) A student burned some ethanol.

Figure 4 shows the apparatus the student used.



(i) The student recorded the temperature of the water before and after heating.

His results are shown in **Table 1**.

Table 1

Temperature before heating	20.7 °C
Temperature after heating	35.1 °C

Calculate the energy used to heat the water.

(c) (i) ± 3024 (J)

correct answer with or without working gains 3 marks

if the answer is incorrect, award up to 2 marks for the following steps:

- $\Delta T = 14.4$ (°C)
- $50 \times 4.2 \times 14.4$

allow ecf for incorrect ΔT

(ii) **Table 2** shows the mass of the spirit burner before the ethanol was burned and after the ethanol was burned.

Table 2

Mass of spirit burner before ethanol was burned	72.80 g
Mass of spirit burner after ethanol was burned	72.10 g

Calculate the number of moles of ethanol (C_2H_5OH) that were burned.

Relative atomic masses (A_r): H = 1; C = 12; O = 16

(ii) 0.015(2173913)

correct answer with or without working gains 3 marks

if answer is incorrect, allow 1 mark each for any of the following steps up to a max of 2.

- 0.70g
- M_r of ethanol = 46
- 0.70 / 46

allow ecf in final answer for arithmetical errors

3

(3)

(iii) Calculate the energy released in joules per mole.

You should assume that all the energy from the ethanol burning was used to heat the water

(iii) $\pm 198\,720$ (J / mole)

c(i) \div c(ii)

allow ecf from (c)(i) and (c)(ii)

0.015 gives 201600

0.0152 gives 198947

0.01522 gives 198686

1

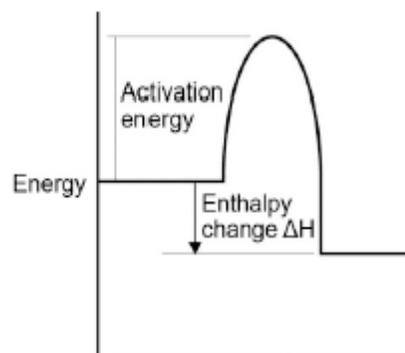
(c) Methane burns in oxygen.

- (i) The diagram below shows the energy level diagram for the complete combustion of methane.

Draw and label arrows on the diagram to show:

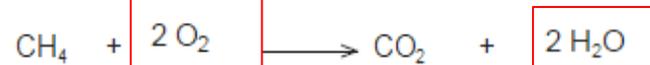
- (c) (i) activation energy labelled from level of reagents to highest point of curve
ignore arrowheads

enthalpy change labelled from reagents to products



*arrowhead **must** go from reagents to products only*

- (ii) Complete and balance the symbol equation for the complete combustion of methane.



*if not fully correct, award 1 mark for all formulae correct.
ignore state symbols*

- (iii) Explain why the **incomplete** combustion of methane is dangerous.

- (iii) carbon monoxide is made

this combines with the blood / haemoglobin **or** prevents oxygen being carried in the blood / round body **or** kills you **or** is toxic **or** poisonous

dependent on first marking point

- (iv) Explain why, in terms of the energy involved in bond breaking and bond making, the combustion of methane is exothermic.

- (iv) energy is taken in / required to break bonds
accept bond breaking is endothermic

energy is given out when bonds are made
accept bond making is exothermic

the energy given out is greater than the energy taken in
this mark only awarded if both of previous marks awarded

(2)

(d) Methane reacts with chlorine in the presence of sunlight.

The equation for this reaction is:



Some bond dissociation energies are given in the table.

Bond	Bond dissociation energy in kJ per mole
C-H	413
C-Cl	327
Cl-Cl	243
H-Cl	432

(i) Show that the enthalpy change, ΔH , for this reaction is -103 kJ per mole.

(d) (i) energy to break bonds = 1895
calculation with no explanation max = 2

energy from making bonds = 1998

1895 - 1998 (= -103)

or

energy to break bonds = 656

energy from making bonds = 759

656 - 759 (= -103)

allow:

bonds broken - bonds made =

413 + 243 - 327 - 432 = -103 for 3 marks.

(ii) Methane also reacts with bromine in the presence of sunlight.



This reaction is less exothermic than the reaction between methane and chlorine.

The enthalpy change, ΔH , is -45 kJ per mole.

What is a possible reason for this?

Tick (✓) **one** box.

CH₃Br has a lower boiling point than CH₃Cl

(ii) The C — Br bond is weaker than the C — Cl bond

1

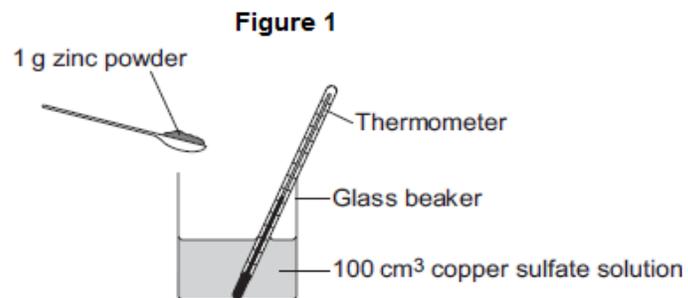
The H-Cl bond is weaker than the H-Br bond.

Chlorine is more reactive than bromine.

(3)

(1)
(Total 15 marks)

A student investigates the energy released when zinc powder reacts with copper sulfate solution. The student uses the apparatus shown in **Figure 1**.



The student:

- measures 100 cm³ copper sulfate solution into a beaker
- measures the temperature of the copper sulfate solution
- puts 1 g zinc powder into the beaker
- stirs the mixture with a thermometer
- measures the highest temperature.

The student's results were:

Starting temperature = 21 °C
Highest temperature = 32 °C

- (a) (i) Calculate the change in temperature.

Change in temperature = 11 °C

- (ii) Calculate the energy released in the reaction.

(ii) 4620 (J)
correct answer gains 2 marks with or without working
allow 4.62kJ for 2 marks
if answer is incorrect:
100 × 4.2 × 11 gains 1 mark
or
100 × 4.2 × (their temp. rise) gains 1 mark
or
100 × 4.2 × (their temp. rise) correctly calculated gains 2 marks

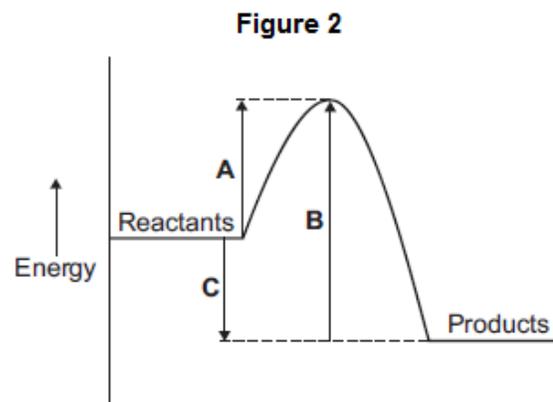
- (b) The reaction of zinc with copper sulfate is exothermic.

How can you tell from the student's results that the reaction is exothermic?

the temperature increases
 allow gets hotter
 allow heat / energy is given off

(1)

- (c) The energy diagram for the reaction is shown in **Figure 2**.



- (i) How can you tell from the energy diagram that the reaction is exothermic?

(energy of) products lower than (energy of) reactants
 allow converse
 allow arrow C points downwards

(1)

(1)

- (ii) Which arrow shows the activation energy in **Figure 2**?

Tick (✓) **one** box.

A	(ii) A	C	<input type="checkbox"/>
B	<input type="checkbox"/>		

(2)

(a) Which sub-atomic particles are present in the nucleus of an atom?

neutron(s)

and

proton(s)

(2)

(b) There are two isotopes of the element chlorine:



Describe, in terms of sub-atomic particles, **one** similarity and **one** difference between atoms of the two isotopes of chlorine.

Similarity: same number (17) protons **or** same number electrons

if candidate chooses to quote numbers, they must be correct

Difference:

different numbers of neutrons (${}^{35}\text{Cl}$ has 18 and ${}^{37}\text{Cl}$ has 20)

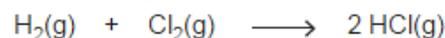
(2)

(c) Chlorine reacts with hydrogen to produce hydrogen chloride.

(i) The table shows the values of some bond dissociation energies.

Bond	H—H	Cl—Cl	H—Cl
Dissociation energy in kJ per mole	436	242	431

Use the values in the table to calculate the enthalpy change (ΔH) for the reaction.



-184kJ / mol

correct answer with or without working gains 3 marks

allow 2 marks for 184 kJ / mol

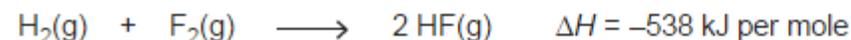
If answer incorrect award up to 2 marks for any two of the steps below:

- bonds broken: $(436 + 242) = 678$ (kJ)*
- bonds formed: $(2 \times 431) = 862$ (kJ)*
- bonds broken - bonds formed*

allow ecf for arithmetical errors

(3)

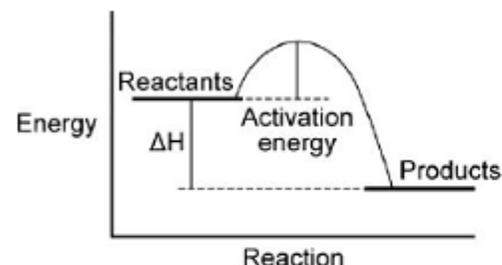
(ii) Hydrogen also reacts with fluorine.



Draw an energy level diagram for this reaction.

Include on your diagram labels to show:

- the reactants and the products
- the overall enthalpy change (ΔH)
- the activation energy.



the reactants and the products at the correct level

ignore labels on the axes

1

ΔH correctly labelled

allow -538 if in correct place

1

E_a correctly labelled

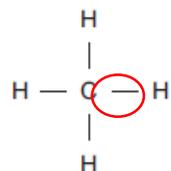
correctly labelled endothermic reaction gains max. 2 marks

1

(3)

Methane (CH₄) is used as a fuel.

(a) The displayed structure of methane is:



circle round any one (or more) of the covalent bonds
any correct indication of the bond – the line between letters

(b) Why is methane a compound?

Tick (✓) **one** box.

Methane contains atoms of two elements, combined chemically

Methane is not in the periodic table.

Methane is a mixture of two different elements.

(iv) Explain why, in terms of the energy involved in bond breaking and bond making, the combustion of methane is exothermic.

energy is taken in / required to break bonds
accept bond breaking is endothermic

energy is given out when bonds are made
accept bond making is exothermic

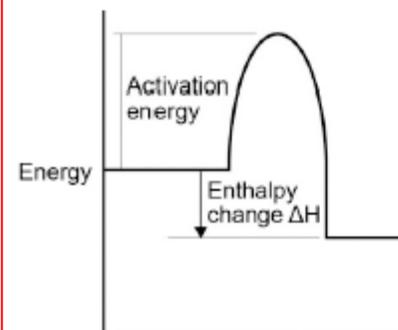
the energy given out is greater than the energy taken in
this mark only awarded if both of previous marks awarded

(c) Methane burns in oxygen.

(i) The diagram below shows the energy level diagram for the complete combustion of methane.

(i) activation energy labelled from level of reagents to highest point of curve
ignore arrowheads

enthalpy change labelled from reagents to products



*arrowhead **must** go from reagents to products only*

(1)

(1)

(ii) Complete and balance the symbol equation for the complete combustion of methane.



(iii) Explain why the **incomplete** combustion of methane is dangerous.

carbon monoxide is made

this combines with the blood / haemoglobin **or** prevents oxygen being carried in the blood / round body **or** kills you **or** is toxic **or** poisonous

dependent on first marking point

(3)

(2)

(2)

(2)

(d) Methane reacts with chlorine in the presence of sunlight.

The equation for this reaction is:



Some bond dissociation energies are given in the table.

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energy to break bonds = 1895

calculation with no explanation max = 2

energy from making bonds = 1998

1895 - 1998 (= -103)

or

energy to break bonds = 656

energy from making bonds = 759

656 - 759 (= -103)

allow:

bonds broken - bonds made =

413 + 243 - 327 - 432 = -103 for 3 marks.

(ii) Methane also reacts with bromine in the presence of sunlight.



This reaction is less exothermic than the reaction between methane and chlorine.

The enthalpy change, ΔH , is -45 kJ per mole.

What is a possible reason for this?

Tick (✓) **one** box.

CH_3Br has a lower boiling point than CH_3Cl

The C — Br bond is weaker than the C — Cl bond

The H-Cl bond is weaker than the H-Br bond.

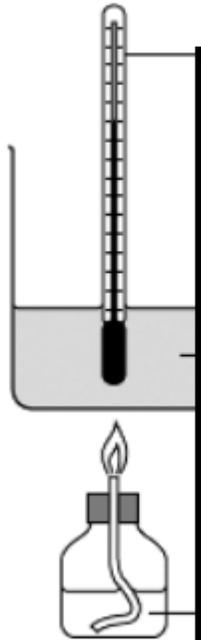
Chlorine is more reactive than bromine.

(3)

(1)

- (a) A student burned three liquid fuels and compared the amounts of energy they produced.

The diagram shows the apparatus the student used.



(a) (i) gives out as much energy / heat as A
accept gives out most energy / heat
ignore temperature

not smoky

or

no / less pollution

Fuel	Mass of fuel burned in g	Temperature increase in °C	Type of flame
A	1	5	smoky
		4	not smoky
		5	not smoky

ed that fuel C was the best fuel.

1

y.

1

The heat produced when each fuel was burned increased the temperature of 100 g of water.

The table shows the student's results.

- (ii) Use the following equation to calculate the energy change for burning 1 g of fuel A.

energy change in joules = $100 \times 4.2 \times$ temperature increase for 1 g of fuel

.....
.....

Answer = J

(1)

- (b) (i) Draw a ring around the

Energy is usually measured in

(ii) 2100 or 2.1kJ

ignore working

1

(b) (i) calories

1

Some food labels give energy

(ii) less obesity

owtte

or

less heart disease

or

so that diet can be balanced

1

Food can help towards a

.....
.....
.....

(1)

(Total 5 marks)

In one experiment the temperature of 50 g of water increased from 22.5 °C to 38.3 °C. The mass of alcohol burned was 0.85 g.

(i) The
usin

(b) (i) 3318 or 3320 (J)

*correct answer with or without
working gains 2 marks*

*if answer incorrect, allow 1 mark for
correct working, eg:*

Calc
burn

*temperature change = (38.3 – 22.5 =)
15.8 or Q = (50 x 4.2 x 15.8 =)*

allow ecf from temp change

2

Ass

the alcohol is used to heat the water (specific heat capacity of water = 4.2 J / g / °C).

.....

.....

- (iv) The heat energy given out when 1 g of ethanol (C_2H_5OH) is burned is 29.7 kJ.

Calculate the heat energy, in kilojoules, that will be given out when 1 mole of ethanol is burned.

Give your answer to three significant figures.

Relative atomic masses: H = 1; C = 12; O = 16

.....
.....
.....
.....

Heat energy =

(iv) 1370

correct answer with or without working gains 3 marks

(M_r ethanol =) 46 gains 1 mark

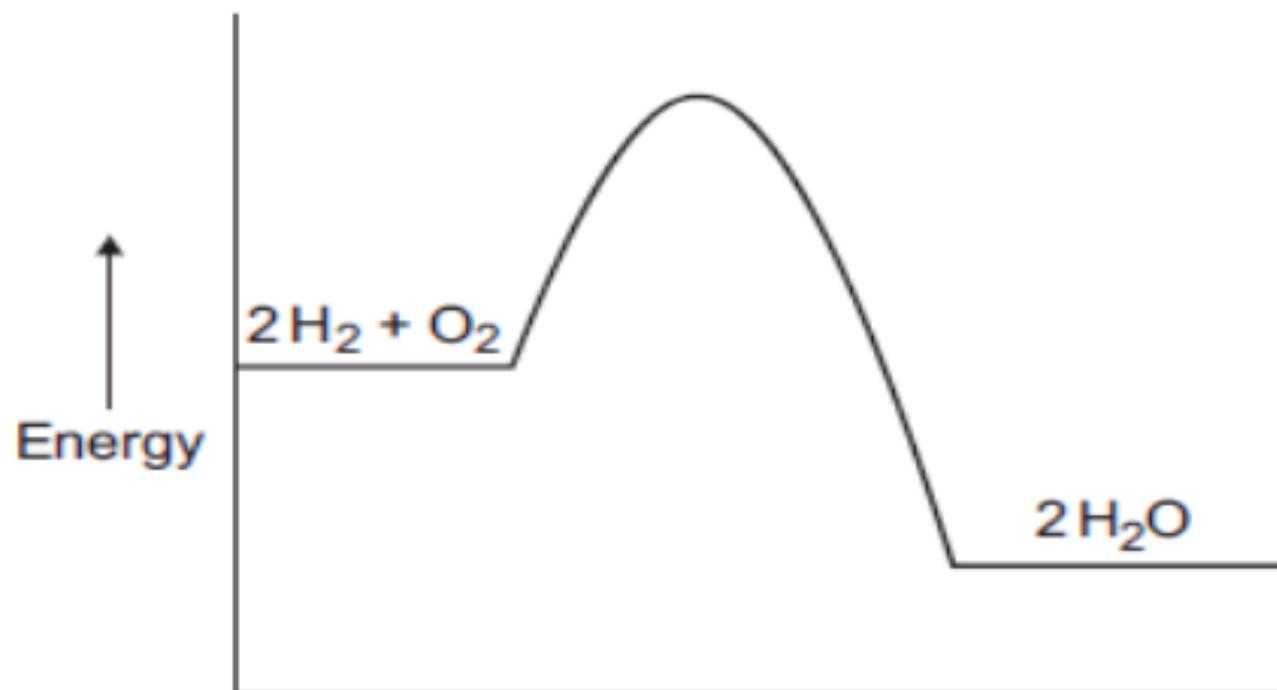
46×29.7 gains 2 marks

max 2 marks if incorrect sig figs (1366.2, 1366, 1400)

final answer ecf on incorrect M_r max 2 marks

The energy level diagram for this reaction is shown in **Figure 3**.

Figure 3



Mark clearly with a cross (x) on **Figure 3** where bond breaking happens.

(c) X on rising section of *line*

(ii) In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

Describe how the student should do this experiment

You should include any measurements that the student should make.

Do not describe any improvements to the experiment

Do not describe how to do any calculations

.....

.....

.....

.....

.....

Examples of the point that may be made in the response

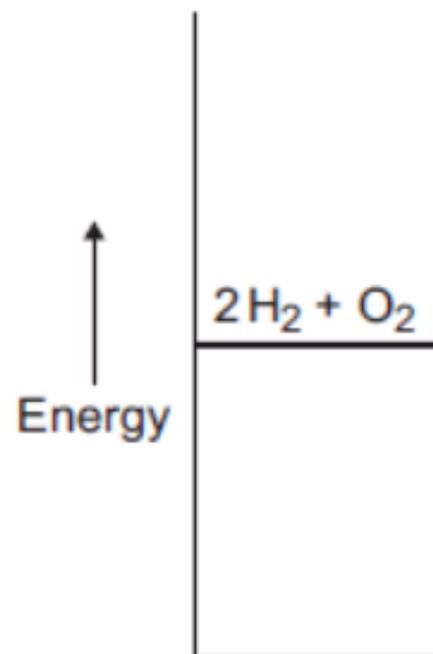
- *light ethanol and heat water*
- *extinguish ethanol*
- *after suitable temperature rise or after a suitable time*
- *stir water*
- *measure mass / volume of water*
- *measure initial temperature of water*
- *measure final temperature of water*
- *measure temperature rise*
- *measure initial mass of ethanol (and burner)*
- *measure final mass of ethanol (and burner)*
- *measure change in mass of ethanol*

(ii) The reaction of hydrogen with oxygen is exothermic.

Complete the energy level diagram for this reaction on **Figure 4**.

Clearly label the activation energy.

Figure 4



(ii) products lower than reactants

1

reaction curve correctly drawn

1

activation energy labelled

1

(iii) Energy produced by food components is usually given in kilocalories.

Which other energy unit is also used ?

Draw a ring around your answer.

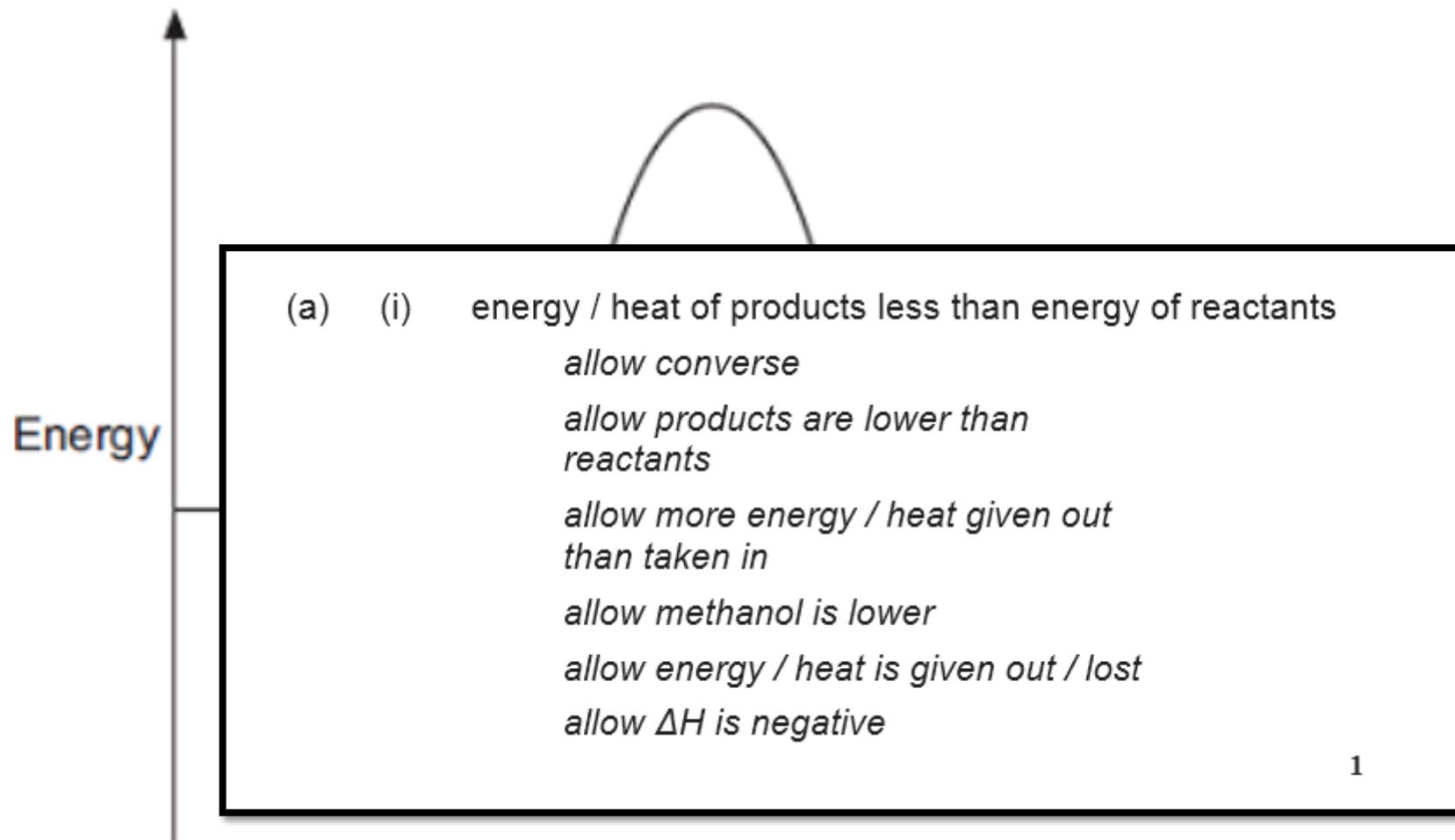
kilograms

kilojoules

kilometres

(1)





- (i) How does the diagram show that this reaction is exothermic?
-

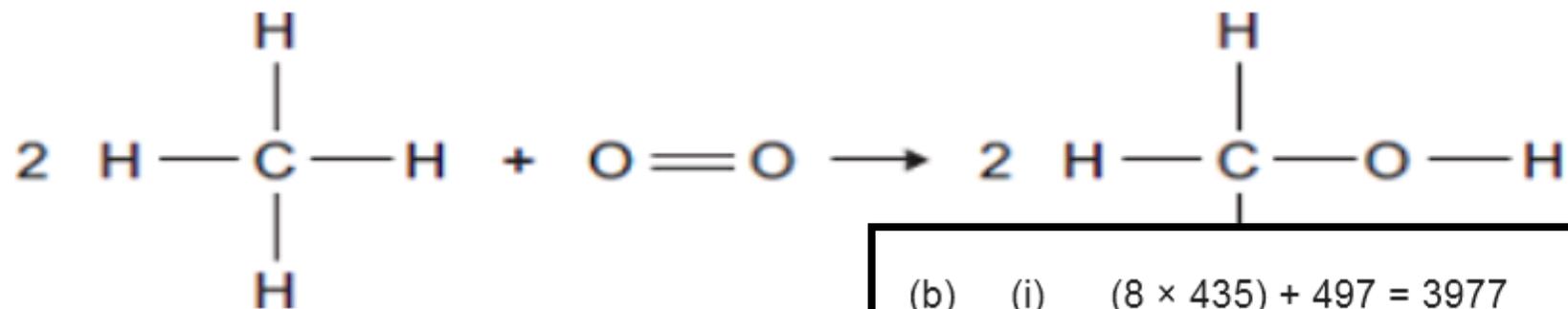
- (ii) A platinum catalyst can be used to increase the rate of this reaction.

What effect does adding a catalyst have on the energy level diagram?

(ii) lowers / less activation energy
allow lowers energy needed for reaction
or it lowers the peak/ maximum
do not allow just 'lowers the energy'

1

(1)



(i) Use the bond energies given below to calculate the energy change for the reaction.

Bond
C—H
O=O
C—O
O—H

(b) (i) $(8 \times 435) + 497 = 3977$

accept: bonds broken: $(2 \times 435) + 497 = 1367$

1

$(6 \times 435) + (2 \times 336) + (2 \times 464) = 4210$

bonds made: $(2 \times 336) + (2 \times 464) = 1600$

1

$3977 - 4210 = (-) 233$

energy change:

$1367 - 1600 = (-) 233$

ignore sign

allow ecf

correct answer (233) = 3 marks with or without working

1

Nanoparticles have many uses.

(a) (i) Tick (✓) **one** use of nanoparticles.

In the extraction of iron

In suntan creams



In the test for oxygen

(1)

- (ii) How is the size of nanoparticles different from normal-sized particles?

Draw a ring around the correct answer.

much smaller

same size

much larger

(1)

(ii) Much smaller

- (b) Very small amounts of cerium oxide nanoparticles can be added to diesel fuel.

The cerium oxide is a catalyst.

- (i) Draw a ring around the correct answer to complete the sentence.

Only a very small amount of cerium oxide nanoparticles is needed because

the nanoparticle

the nanoparticles

are elements.

are very reactive.

have a high surface area to volume ratio.

(1)

(ii) Explain how a catalyst increases the rate of a reaction.

(ii) because a catalyst provides an alternative /
different pathway / mechanism / reaction route

*accept adsorption or 'increases
concentration at the surface' ignore
absorption*

1

(that has) lower activation energy

allow weakens bonds

*allow idea of increased successful
collisions*

(a) Which sub-atomic particles are present in the nucleus of an atom?

.....
and

(a) neutron(s)

answers can be in either order

1

(b) There are

proton(s)

1

(b) same number (17) protons or same number electrons

if candidate chooses to quote numbers, they must be correct

1

Describe
one difference

different numbers of neutrons (^{35}Cl has 18 and ^{37}Cl has 20)

1

Similarity

Difference

(c) Chlorine reacts with hydrogen to produce hydrogen chloride.

(i) The table shows the values of some bond dissociation energies.

Bond	H—H
Dissociation energy in kJ per mole	436

Use the values in the table to calculate the enthalpy change (ΔH) for the reaction.



(c) (i) -184kJ / mol

correct answer with or without working gains 3 marks

allow 2 marks for 184 kJ / mol

If answer incorrect award up to 2 marks for any two of the steps below:

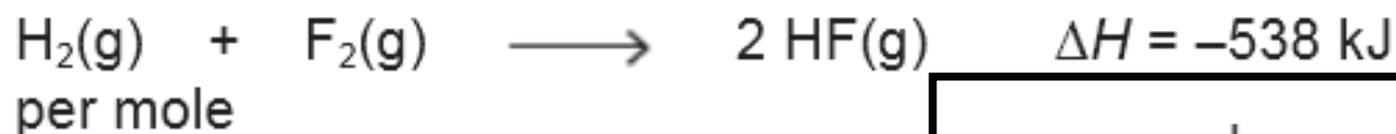
- *bonds broken: $(436 + 242) = 678$ (kJ)*

- *bonds formed: $(2 \times 431) = 862$ (kJ)*

- *bonds broken – bonds formed*

allow ecf for arithmetical errors

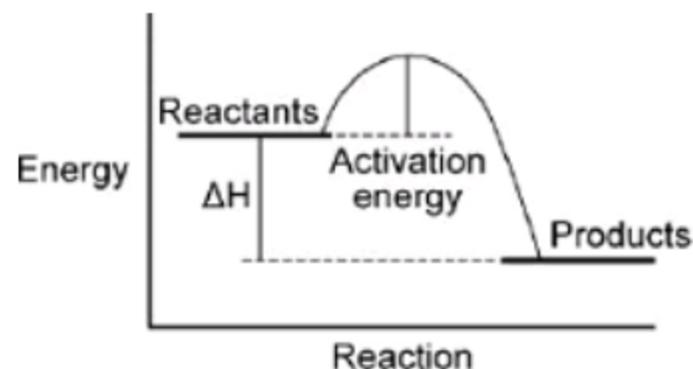
(ii) Hydrogen also reacts with fluorine.



Draw an energy level diagram for this reaction.

Include on your diagram labels to show:

- the reactants and the products
- the overall enthalpy change (ΔH)
- the activation energy.



the reactants and the products at the correct level
ignore labels on the axes

1

ΔH correctly labelled
allow -538 if in correct place

1

E_a correctly labelled
*correctly labelled endothermic reaction
gains max. 2 marks*

1

Some information about propane and hydrogen is given in the table.

Fuel	Resource	Products formed when fuel burned
propane	crude oil	carbon dioxide and water
hydrogen	water	water

Use the information in the table to suggest two reasons why hydrogen is a better fuel than propane.

1

.....

2

(c) carbon dioxide produced
it = propane
allow converse arguments
allow greenhouse gas / global warming / atmospheric pollution

(crude oil / propane) non-renewable 1

allow crude oil running out 1

The equation for the combustion of propane is:



Some bond energies are given in the table

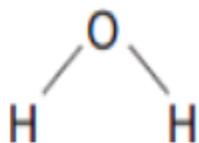
Bond	Bond Energy in kJ per mole
$\text{C}=\text{O}$	830
$\text{O}-\text{H}$	464

The displayed structures of the products are:

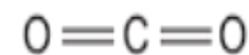
carbon dioxide



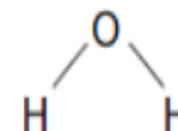
water



carbon dioxide



water



(b) (i) 8530

correct answer gains 3 marks with or without working.

If answer is incorrect;

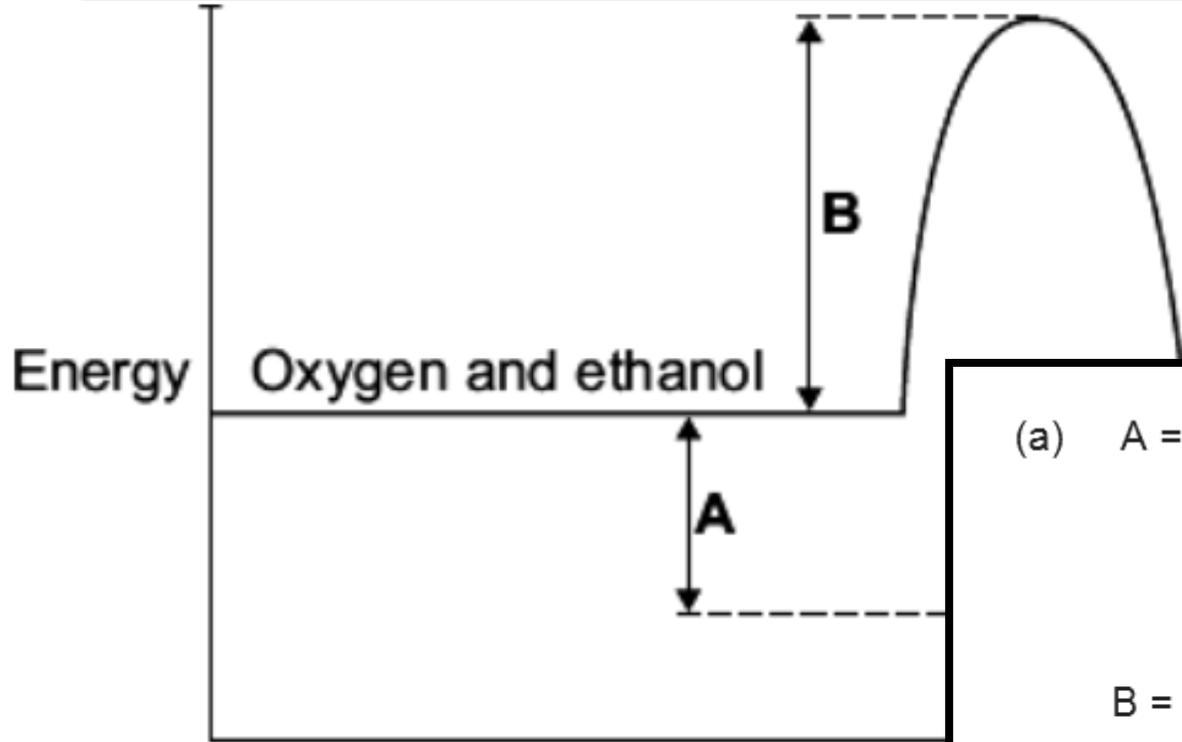
(6 x 803) = 4818 gains 1 mark

(8 x 464) = 3712 gains 1 mark

correct addition of their calculated values gains 1 mark (ecf)

3

Energy released = kJ per mole



(a) A = <u>energy</u> / <u>enthalpy</u> change / difference <i>allow heat change or ΔH</i> <i>allow energy released</i>	1
B = activation energy / EA <i>allow definition of activation energy</i>	1
C = carbon dioxide and water <i>accept products</i>	1

(a) On the energy level diagram what is

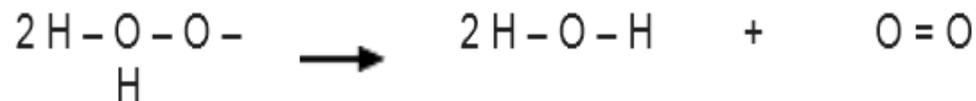
A

B

C

(3)

- (a) The equation for the reaction can be represented using structural formulae.



Use the bond energies in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ per mole
H - O	464
O - O	146
O = O	498

- (a) correct answer with or without working = 3 marks

M1: (bonds broken) = 2148 (kJ)

1

M2: (bonds made) = 2354 (kJ)

1

M3: change in energy
= (-) 206 (kJ)

ecf

ignore sign

1

= kJ

(3)

- (b) energy released from forming new bonds is greater than energy needed to break existing bonds

allow the energy needed to break bonds is less than the energy released in forming bonds

do not accept energy needed to form bonds

1

Hydrogen peroxide decomposes slowly to give water and oxygen.

The reaction is *exothermic*.



- (a) In an *exothermic* reaction, energy is given out.

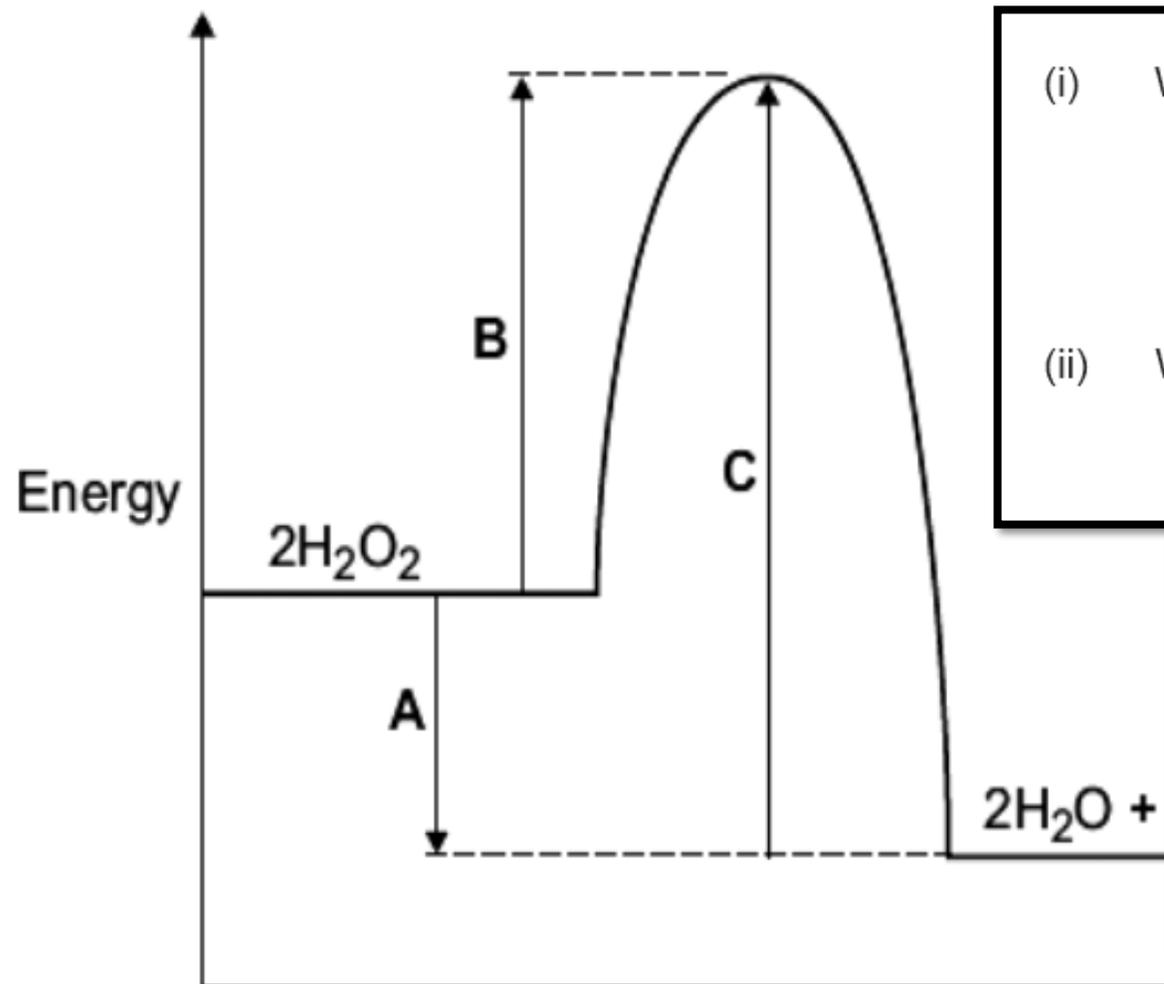
Draw a ring around the correct answer to complete the sentence.

In an *exothermic* reaction, the temperature

(a) goes up

1

stays the same.



(i) Which energy change, **A**, **B** or **C**, is the activation energy?

(1)

(ii) Which energy change, **A**, **B** or **C**, shows that this reaction is exothermic?

(1)

(a) goes up

1

(b) (i) B

1

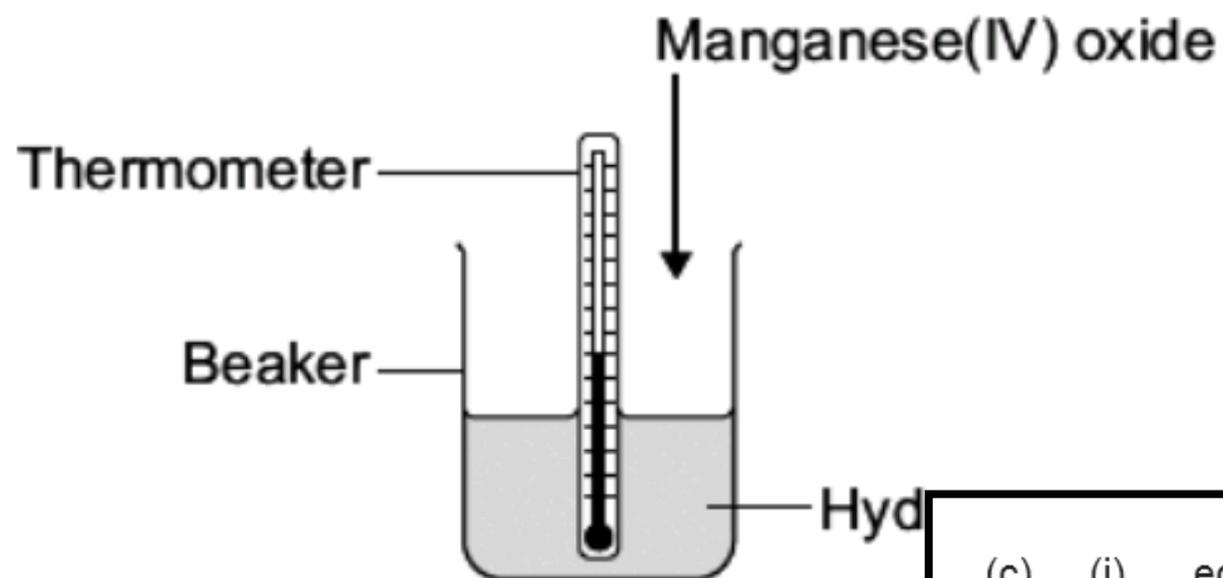
(ii) A

1

The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide and stirred the mixture and recorded the highest temperature.

(i) Suggest why the student stirred the mixture when recording the highest temperature.

(c) (i) eg (ensures) complete reaction
allow spread heat / energy

or even heating

allow mixes properly or mix them together or to get correct temperature

ignore dissolves

Hydrogen peroxide decomposes slowly to give water and oxygen.

The reaction is *exothermic*.



(a) In an *exothermic* reaction, energy is given out.

Draw a ring around the correct answer in the sentence.

(a) goes up

1

In an *exothermic* reaction, the temperature

goes down.

goes up.

stays the same.

(1)

Hydrogen peroxide decomposes to give water and oxygen.



The reaction is *exothermic*.

(a) Explain, in terms of bond breaking and bond making, why the decomposition of hydrogen peroxide is exothermic.

(a) energy released from making (new) bonds is greater than the energy needed to break (existing) bonds

accept the energy needed to break (existing) bonds is less than the energy released in making (new) bonds

do not accept energy needed to make bonds

1

(1)

In lightning the temperature can reach 30 000 °C. This causes nitrogen and oxygen in the air to react, producing nitrogen oxide. This reaction has a high *activation energy* and is *endothermic*.

(a) Nitrogen and oxygen in the air do not react under normal conditions.

What makes nitrogen and oxygen react during thunderstorms?

.....

(a) electricity / (high) temperatures
allow lightning / heat
ignore energy

1

(b) nitrogen + oxygen → nitrogen oxide/ monoxide
allow any oxide of nitrogen

1

(b) Complete the word equation for the reaction of nitrogen with oxygen.

nitrogen + →

(1)

(b) What is meant by the term *activation energy*?

(b) (minimum) energy needed to start the reaction / overcome energy barrier

accept (minimum) energy needed for a collision to be successful

1

(1)

When a known mass of a hydrocarbon was completely burned in oxygen, 17.6 g of carbon dioxide and 7.2 g of water were the only products.

Relative formula masses (M_r): CO_2

Use this information to calculate the mass of carbon dioxide and of water produced in the reaction. Then calculate the empirical formula of the hydrocarbon.

You must show your working to gain full marks.

.....

.....

.....

$\frac{17.6}{44}$ (moles) or 0.4 (moles) CO_2	1
$\frac{7.2}{18}$ (moles) or 0.4 (moles) H_2O	1
empirical formula = CH_2 <i>allow 1C:2H</i> <i>or correct simplest ratio related to elements</i> <i>or ecf from previous stage</i> <i>allow this mark for correct formula alone</i>	1

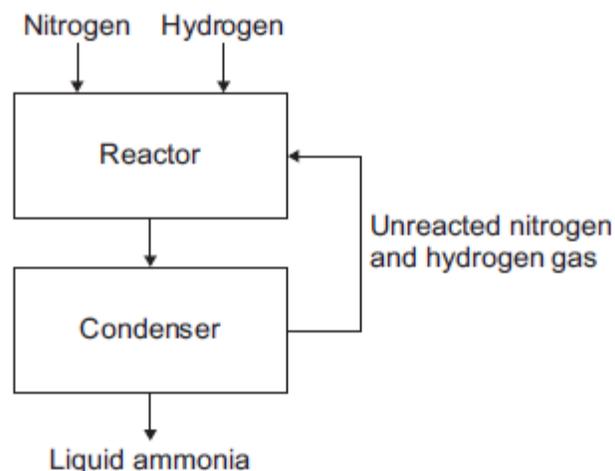
C3 chapter 4: analysis and synthesis

1- flame test

- 1 name a way in which you can test for positive ions?
 - 2 Which metal ions give red colours in a flame?
 - 3 what are the three tests for negative ions?
 - 4 why is an indicator needed in acid-alkali titrations?
 - 5 name the equation to work out number of moles?
 - 6 when is it necessary to use quantitative analysis?
 - 7 explain what it is meant by equilibrium?
 - 8 If a reversible reaction is exothermic one way, what is it the other way?
 - 9 write a word equation for the manufacture of ammonia?
 - 10 what is done in the haber process to conserve raw materials?
 - 11 why do higher pressures increase the costs of an industrial process?
 - 12 what conditions are used in the haber process?
- 2- lithium and calcium
- 3- carbonate ions, halide ions and sulfate ions
- 4-to show when the reaction is complete
- 5- n.o of moles=mass (grams) divided by relative formula mass
- 6- when we need to know how much or the quantity of a substance in a sample
- 7- when the rates of the forward and reverse reactions of a reversible reaction are equal or when the amounts of reactants and products in a reversible reaction are constant
- 8- endothermic
- 9- nitrogen+hydrogen(reversible reaction symbol) ammonia
- 10- unreacted gases are recycled
- 11- more energy is needed and stronger reaction vessels a pipes are needed which are expensive
- 12- 200 atmospheres of pressure, 450°C temperature and an iron catalyst

A flow diagram of the Haber process is shown below.

The Haber process produces ammonia from nitrogen and hydrogen.



(a) Use the correct answer from the box to complete the sentence.

air **limestone** **natural gas**

Hydrogen is obtained from **natural gas**

(b) In the reactor, nitrogen and hydrogen at a high pressure are heated and a catalyst.

(i) Use the correct answer from the box to complete the sentence.

25 **100** **450**

The temperature in the reactor is **450** °C

(ii) Use the correct answer from the box to complete the sentence.

copper **iron** **nickel**

The catalyst used in the reactor is **iron**

(1)

(iii) How does a catalyst speed up a reaction?

Tick (✓) **one** box.

The catalyst lowers the activation energy.

The catalyst gives the reactants extra energy.

The catalyst increases the pressure in the reactor.

(1)

(c) A mixture of gases leaves the reactor.

The mixture contains ammonia, nitrogen and hydrogen.

Describe what happens to this mixture of gases in the condenser.

(the gases are) cooled 1
ammonia condenses
allow ammonia liquefies 1
nitrogen and hydrogen are recycled
if no other mark awarded allow ammonia is separated for 1 mark 1

(3)

(b) How are the elements in the periodic table arranged?

Tick (✓) **one** box.

In order of increasing atomic number

(b) In order of increasing atomic number

1

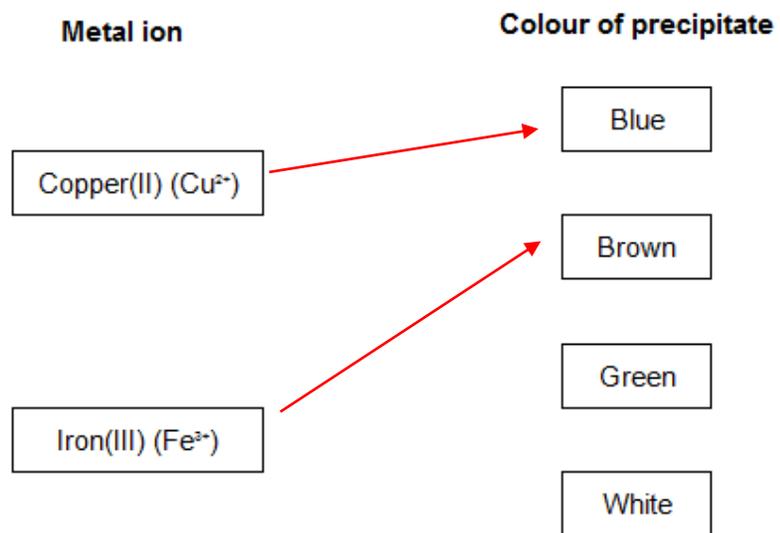
In order of increasing mass number

In order of increasing reactivity

This question is about chemical tests.

- (a) Solutions of copper(II) ions and iron(III) ions produce coloured precipitates with sodium hydroxide solution.

Draw **one** line from each metal ion to the colour of the precipitate it produces.



- (b) Sodium hydroxide solution was added to a solution containing ions of a metal.

A white precipitate was produced. The white precipitate dissolved in excess sodium hydroxide solution.

Use the correct answer from the box to complete the sentence.

aluminium magnesium potassium

The ions in the solution were ions of aluminium

- (c) Low sodium salt contains sodium chloride and potassium chloride.

A student used a flame test on low sodium salt.

- (i) What is the colour produced by sodium ions in a flame test?

yellow
allow orange

(1)

- (ii) What is the colour produced by potassium ions in a flame test?

lilac
allow purple

(1)

- (iii) Why is it **not** possible to tell from the flame test that both ions are present in low sodium salt?

one colour masks the other
allow colours mixed

(1)

(2)

(1)

This question is about chemical analysis.

(a) A student has solutions of three compounds, **X**, **Y** and **Z**.

The student uses tests to identify the ions in the three compounds.

The student records the results of the tests in the table.

Compound	Test			
	Flame test	Add sodium hydroxide solution	Add hydrochloric acid and barium chloride solution	Add nitric acid and silver nitrate solution
X	no colour	green precipitate	white precipitate	no reaction
Y	yellow flame	no reaction	no reaction	yellow precipitate
Z	no colour	brown precipitate	no reaction	cream precipitate

Identify the **two** ions present in each compound, **X**, **Y** and **Z**.

X:

Fe²⁺ / iron(II), SO₄²⁻ / sulfate

*allow iron(II) sulfate
or FeSO₄*

1

Y:

Na⁺ / sodium, I⁻ / iodide

*allow sodium iodide
or NaI*

1

Z:

Fe³⁺ / iron(III), Br⁻ / bromide

*allow iron(III) bromide
or FeBr₃*

correct identification of any two ions = one mark

correct identification of any four ions = two marks

1

(3)

(b) A chemist needs to find the concentration of a solution of barium hydroxide. Barium hydroxide solution is an alkali.

The chemist could find the concentration of the barium hydroxide solution using two different methods.

Method 1

- An excess of sodium sulfate solution is added to 25 cm³ of the barium hydroxide solution. A precipitate of barium sulfate is formed.
- The precipitate of barium sulfate is filtered, dried and weighed.
- The concentration of the barium hydroxide solution is calculated from the mass of barium sulfate produced.

Method 2

- 25 cm³ of the barium hydroxide solution is titrated with hydrochloric acid of known concentration.
- The concentration of the barium hydroxide solution is calculated from the result of the titration.

Compare the advantages and disadvantages of the two methods.

any **five** from:

allow converse arguments

method 1

- weighing is accurate
- not all barium sulfate may be precipitated
- precipitate may be lost
- precipitate may not be dry
- takes longer
- requires energy

allow not all the barium hydroxide has reacted

method 2

- accurate
- works for low concentrations

allow reliable / precise

(5)

A student was investigating a magnesium salt, **X**.

The student found that **X**:

- has a high melting point
- does not conduct electricity
- dissolves in water and the solution conducts electricity.

(a) (i) What is the type of bonding in magnesium salt **X**?

ionic (bonding)

(1)

(ii) Explain why solid **X** does **not** conduct electricity but a solution of **X** does conduct electricity.

ions cannot move in solid **or** are in fixed positions
do **not** accept electrons / atoms / molecules
ignore particles
must mention ions

(2)

(b) The student dissolved **X** in water.

The student added dilute nitric acid and silver nitrate solution to the solution of **X**.

A white precipitate was formed.

Salt **X** contains chloride ions.

Explain why a white precipitate was formed.

silver chloride formed

1

which is insoluble

1

(c) The student dissolved **X** in water.

The student added a few drops of sodium hydroxide solution to the solution of **X**.

A white precipitate was formed.

(i) Salt **X** contains magnesium ions.

Name **two** other metal ions that would give a white precipitate when a few drops of sodium hydroxide solution are added.

1 aluminium

2 calcium

accept other metal ions that also give white precipitates (such as lead and zinc)

(2)

(ii) Describe the **two** further tests the student would have to do to show that salt **X** contains magnesium ions, and **not** the two metal ions you identified in part (c) (i).

Give the expected results of each test.

add excess sodium hydroxide solution

the second mark of each pair is dependent on the first mark being awarded.

1

precipitate remains

1

carry out a flame test

1

not red / orange

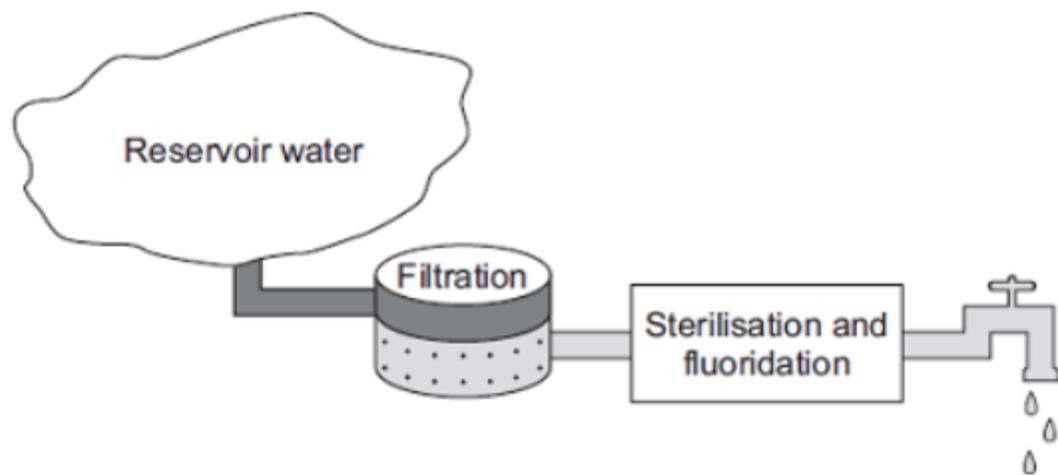
accept any colour that is not orange / red

give full credit for answers that correctly eliminate other cations in (c) (i) that would give white precipitates with a few drops of NaOH

1

4)

The diagram shows three stages in the treatment of reservoir water.



(a) (i) What is separated from the reservoir water during filtration?

Tick (✓) **one** box.

Bacteria

Dissolved nitrates

Solids

(ii) What is added to sterilise the water?

Tick (✓) **one** box.

Calcium

Chlorine

Magnesium

(iii) State **one** advantage of adding fluoride to drinking water.

.....
.....

(a) (i) Solids

1

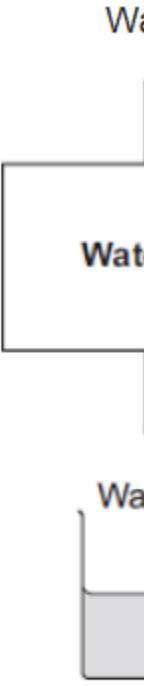
(ii) Chlorine

1

(iii) improves dental health or reduces tooth decay

1

(b) The diagram shows a water filter used in the home.



(c) Seawater contains dissolved sodium chloride.

(a) (i) Solids

1 presence of sodium ions

(ii) Chlorine

1

(iii) improves dental health or reduces tooth decay

1

(b) put a sample of the filtered water in an evaporating basin or leave to evaporate

1

accept any description of evaporation (using a Bunsen or leaving on the windowsill)

1 drinking water. (2)

there will be crystals of salt left

1

A student collected a sample of water

(c) (i) **Test** – flame test

1

The student could show that the filter residue is sodium chloride without using a chemical test.

Result – yellow / orange / persistent orange flame

1

Describe how.

(ii) sodium and / or chloride ions are bigger than water (molecules) or ions are charged or molecules are not charged

1 he membrane, but

do not accept sodium chloride molecules as ions is given in the question

1

(ii) Explain why increasing the temperature would increase the rate of reaction.

.....

.....

.....

.....

.....

.....

(ii) particles move faster <i>allow particles have more (kinetic) energy</i>	1
therefore more collisions <u>per unit time</u> or more frequent collisions	1
collisions more energetic (therefore more collisions have energy greater than the activation energy) or more productive collisions	1

- (c) (i) The student had a solution of sodium hydroxide with a concentration of $0.100 \text{ moles per dm}^3$.

She wanted to check the concentration of a solution of hydrochloric acid.

She used a pipette to transfer 5 cm^3 of hydrochloric acid into a conical flask.

She filled a burette with the $0.100 \text{ mol dm}^{-3}$ sodium hydroxide solution.

Describe how she should use the burette to obtain accurate results.

.....

(c) (i) add (a few drops) of indicator to the acid in the conical flask
allow any named indicator

1

add NaOH (from the burette) until the indicator changes colour or add the NaOH dropwise

candidate does not have to state a colour change but penalise an incorrect colour change.

1

repeat the titration

1

calculate the **average** volume of NaOH or repeat until concordant results are obtained

1

Calcium chloride (CaCl_2) is a soluble salt.

Calcium chloride can be made by reacting dilute hydrochloric acid with either solid calcium oxide or solid calcium carbonate.

(a) Name the reaction between dilute hydrochloric acid and calcium oxide.

(a) neutralisation

ignore reference to exothermic or endothermic

1

(b) $2 \text{HCl} + \text{CaO} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O}$

accept multiples and fractions

(1)

(b) Write a balanced equation for the reaction between dilute hydrochloric acid and calcium oxide.

formulae

ignore state symbols

1

balancing (dependent on first mark)

1

(2)

(c) A student added solid calcium oxide to dilute hydrochloric acid in a beaker.

The student added solid calcium carbonate to dilute hydrochloric acid in another beaker.

Describe **one** difference between the two reactions that the student would **see**.

..... (c) (the carbonate has) fizzing / bubbles / effervescence

ignore dissolving

ignore gas produced

1

(1)

(d) Describe how crystals of calcium chloride can be made from calcium carbonate and dilute hydrochloric acid.

(d) add excess calcium carbonate to acid (and stir) / add CaCO_3 until fizzing stops

ignore heating the acid

accept answer using calcium oxide in place of calcium carbonate

1

(remove excess calcium carbonate by) filter(ing)

1

warm until a saturated solution forms / point of crystallisation / crystals start to form

do not accept heat until all water gone

1

leave to cool

dependent on previous marks

(4)

(ii) The student's results are shown in the table below.

Titration	Volume of sodium hydroxide solution added in cm³
1	22.40
2	22.20
3	22.30

Calculate the mean volume of sodium hydroxide solution added.

(ii) 22.3(0)

1

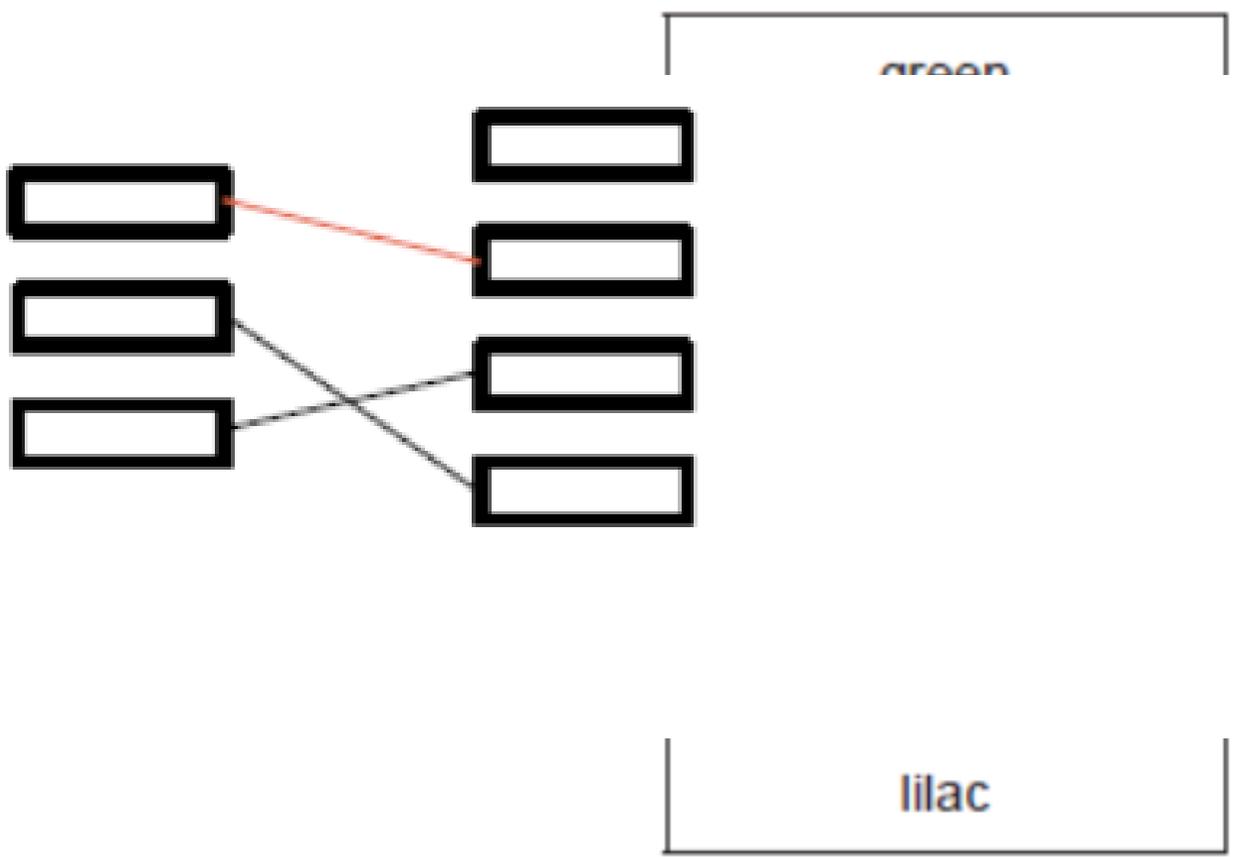
(1)

Chemical

Flame colour

(ii)

po



1
1

(3)

Chemical	Colour produced in firework
barium chloride	green

.....
Ca

(a) lithium

allow Li⁺ / Li

1

sodi

yellow

allow orange

1

calci

(b) silver nitrate (solution)

incorrect test = 0 marks

ignore (nitric) acid

do not allow other named acids

1

(b) Describe a test to show the presence of chloride ions.

white precipitate

1

Give the result of the test.

This question is about reversible reactions and chemical equilibrium.

(a) Reversible reactions can reach equilibrium in a closed system.

(i) What is meant by a closed system?

.....
.....

(ii) Explain why, when a reversible equilibrium, the reaction appears to have stopped.

.....
.....

(a) (i) nothing can enter **and** nothing can leave the reaction
allow sealed reaction vessel

1

(ii) forward and backward reactions have same rate

1

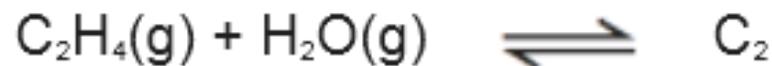
so there is no (overall) change in quantities of reactants and products

allow concentrations of reactants and products

1

A company manufactures ethanol (C₂H₅OH).

The reaction for the process is:



The temperature and pressure are constant. Explain how the yield of ethanol at equilibrium is affected by changes in the conditions.

(a) Explain what is meant by dynamic equilibrium.

.....

.....

.....

.....

(a) the forward and backward reactions occur at the same rate
allow reversible

1

at (exactly) the same rate

1

in a closed system

allow therefore the concentrations / amounts of the reactants and products remain the same

1

(b) (i) increasing the temperature would lower the yield of ethanol or the (position of) equilibrium moves to the left

if student has stated that increasing the temperature increases the yield then award 0 marks

1

- (iii) Use the information in the figure to answer this question.

Draw a ring around the pressure that gives the highest yield of ammonia.

100 200 300 400

- (iv) The pressure used in the Haber process production of ammonia is 200 atmospheres.

Why is a pressure lower than 200 atmospheres used for the Haber process?

.....

.....

(iii) 400	1
(iv) lower yield <i>allow converse</i> <i>accept shifts equilibrium to left</i> <i>allow favours the backward reaction</i> <i>allow favours side with more (gaseous) molecules</i> <i>allow lower rate</i>	1

(1)

- (a) Use the correct word from the box to complete the sentence.

fertilisers

insecticides

pesticides

Ammonium salts
as
the soil.

(a) fertilisers

1

(b) air

1

(1)

- (b) Ammonia is made by reacting nitrogen with hydrogen.

Which raw material provides nitrogen?

Draw a ring around your answer.

air

crude oil

water

(1)

- (c) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Ammonia is manufactured from Haber process:



The forward reaction is exothermic.

The conditions used in the Haber process are:

- 200 atmospheres pressure
- 450 °C
- iron catalyst.

Use the equation and your knowledge to explain why these conditions are used in the Haber process.

200 atmospheres pressure

- high pressure gives a high yield of ammonia
- too high a pressure causes risk of explosion
- high pressure costly to maintain
- a high pressure will cause the rate to be higher
- 4 moles of gas become 2 (or fewer moles of gas in products)

450 °C

- high temperature increases the rate of reaction
- optimum temperature
- (forward reaction is exothermic so) a high yield of ammonia requires a low temperature
- but too low a temperature causes the rate of reaction to be too slow

iron catalyst

- a catalyst speeds up the reaction
- an iron catalyst allows a lower temperature to be used (saving energy and causing a higher yield)
- iron catalyst increases the rate of reaction equally in

Draw a ring around the correct answer to complete the sentence.

The symbol \rightleftharpoons in the word equation is

(a) reversible

1

(b) catalyst

1

slow.

(1)

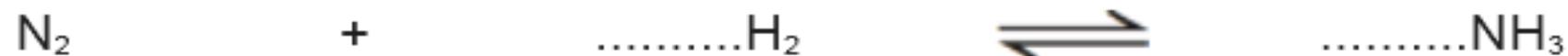
(b) The reactor contains iron.

Complete the sentence.

The iron speeds up the reaction because it is
a

(1)

- (c) Balance the chemical equation below for the production of ammonia.



- (d) A temperature of 450°C is used for the reaction of nitrogen with hydrogen. The forward reaction is exothermic.

Explain why a temperature of 450°C is used for the Haber process.

.....

(c)	$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$	
	<i>allow correct multiples</i>	1
(d)	<i>allow converse arguments</i> <i>ignore references to compromise</i>	
	because a higher temperature would reduce (equilibrium) yield	
	<i>allow higher temperature favours backward reaction</i>	1
	because a lower temperature would reduce rate	1

Ammonia solution is alkaline.

- (i) Draw a ring around the number most likely to be the pH of ammonia solution.

(a)	(i)	10	1
	(ii)	OH^-	1

- (ii) Draw a ring around the ion in ammonia solution which makes it alkaline.

Cl^-

H^+

Na^+

OH^-

(1)

(i) Why does the yield of ammonia at equilibrium increase as the temperature is decreased?

(b) (i) exothermic reaction

.....
.....
accept reverse reaction
endothermic

or
equilibrium / reaction moves in the direction that
raises the temperature

ignore answers based on collisions

(ii) A temperature increase shifts the equilibrium to the left.

Explain, in terms of particles, why increasing temperature makes a reaction go faster.

.....
.....
.....

(ii) they / particles / molecules move faster or have more (kinetic) energy

allow atoms instead of particles
ignore particles move more / vibrate
do not accept electrons (max1)

1

any one from:

- particles / molecules collide more often / more frequently / more likely to collide
ignore collide faster
ignore more collisions
- more of the collisions are successful or particles collide with more energy / harder or more of the particles have the activation energy
accept more successful collisions

In the **reactor** only a small amount of the nitrogen and hydrogen is changed into ammonia.

Tick (✓) the reason why.

Reason why	Tick (✓)
Ammonia is formed from two elements.	
Nitrogen and hydrogen are gases.	
The reaction is reversible.	←

(1)

The forward reaction is exothermic.

(i) Name the raw materials that are used to supply the nitrogen and hydrogen.

(a) (i) nitrogen - air

accept atmosphere

Nitrogen

1

Hydrogen

hydrogen - north sea gas / natural gas / methane / CH₄

accept water / (crude) oil / coal / hydrocarbons / brine

1

(ii) The Haber process

(ii) *allow converse throughout*

Explain, as fully as C is used rather than much lower temperature

- high temperature gives a low yield

1

- because reaction is exothermic
must be linked to first bullet point

1

.....

- but at low temperatures the rate is (too) slow
if no other marks awarded accept 450°C is a compromise between yield

.....

The equation for a reaction to produce hydrogen is:



(a) Explain why changing the temperature affects the yield of hydrogen at equilibrium.

.....
.....

(b) Suggest why the best yield of hydrogen is obtained at **low** temperatures.

.....
.....

(a) same number of (gaseous) molecules / moles / volume on both sides of the equation

allow particles for molecules

do not accept atoms

ignore amount

1

(b) (forward) reaction is exothermic

accept reverse answer

1

To make the greatest percentage yield of ammonia

the temperature should be

- low
- medium
- high

and the pressure

sho

(c)	(i)	low	1
		high	1
		high	

(2)

(b) In the reactor the equation to produce ammonia is:

exothermic

(b) (i) an equilibrium is achieved when rate of the forward reaction is exactly the same as the rate of the backward reaction

1

(ii) in this equilibrium the forward reaction to form ammonia is exothermic

1

therefore if the temperature is low the yield from the exothermic reaction increases

1

(1)

Explain why.

(a) Ammonium sulfate is a fertiliser.

(i) (a) (i) sulfuric 1

neutralisation 1

(ii) add hydrochloric acid / nitric acid
if no barium salt added, no marks 1

then add barium chloride / nitrate (solution) 1

(ii) white precipitate forms if sulfate is present
accept insoluble barium sulfate forms 1

(2)

.....
.....

C3 chapter 5: organic chemistry

1. Name and give the structural formula of the first three members of the homologous series of alcohols.
2. Name and give the structural formula of the first three members of the homologous series of carboxylic acids.
3. Draw the displayed formula of ethyl ethanoate.
4. What properties make ethanol a useful solvent?
5. Describe what happens when a small piece of sodium is added to ethanol.
6. Why does a glass of beer containing 5% ethanol turn sour after a few hours?
7. Describe one reaction of ethanoic acid which is similar to the reactions of all other acids.
8. Ethanol and ethanoic acid can react together to produce an ester. Name the ester and describe the conditions used for the reaction.
9. Suggest why ethyl butanoate is added to some fruit drinks?
10. Suggest one advantage and one disadvantage of using ethanol as an alternative to petrol.
11. I have an aqueous solution of hydrochloric acid and ethanoic acid with the same concentration. What test can I do to tell which is the ethanoic acid?
12. Write a balanced symbol equation for complete combustion of propanol.

11) Test with universal indicator or pH meter.

Ethanoic Acid has a higher pH.
Or add a metal, carbonate and ethanoic acid reacts slower.

production.



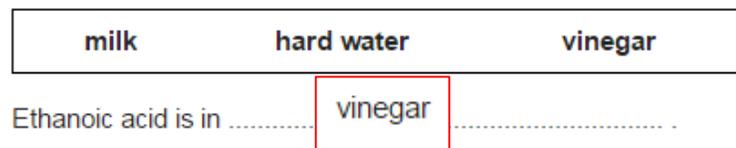
This question is about organic compounds.

(a) Ethanol burns in air.

Use the correct answer from the box to complete the word equation for the reaction.



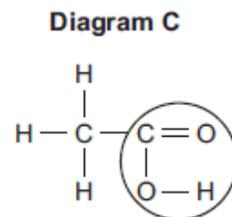
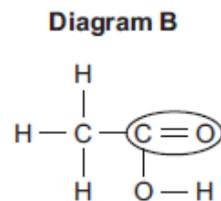
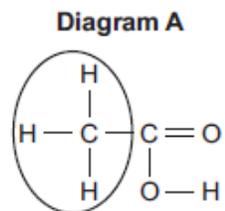
(b) Use the correct answer from the box to complete the sentence.



(c) Ethanoic acid is a carboxylic acid.

Which diagram, **A**, **B** or **C**, has a ring around the functional group of a carboxylic acid?

Write your answer in the box.



Diagram

C

(d) Ethyl propanoate is produced by reacting ethanol with propanoic acid.

What type of organic compound is ethyl propanoate?

Tick (✓) **one** box.

Alcohol

(1)

Carboxylic acid

Ester

(1)

(1)

(e) Organic compounds such as ethyl propanoate are used in perfumes.

Give **two** properties of these compounds that make them suitable for use in perfumes.

pleasant smell

volatile

allow low boiling point / evaporates

(2)

(1)

This question is about organic compounds.

- (a) Ethanol is an alcohol.
One use of ethanol is in alcoholic drinks.

Give **two** other uses of ethanol.

fuel
allow source of energy
solvent
allow perfume / aftershave
antiseptic
allow antibacterial

(2)

- (b) Which gas is produced when sodium reacts with ethanol?

Tick (✓) **one** box.

Carbon dioxide

Carbon monoxide

Hydrogen

Oxygen

(1)

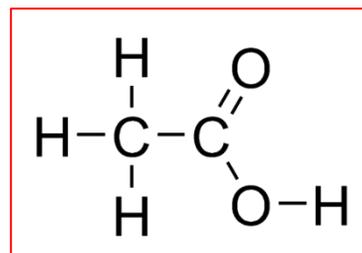
- (c) Ethanoic acid (CH_3COOH) can be produced from ethanol ($\text{CH}_3\text{CH}_2\text{OH}$).

- (i) What type of reaction produces ethanoic acid from ethanol?

oxidation
do **not** allow redox

(1)

- (ii) Complete the displayed structure of ethanoic acid.



(1)

- (iii) Solutions of ethanoic acid and hydrochloric acid with the same concentration have different pH values.

Explain why the solution of ethanoic acid has a higher pH than the solution of hydrochloric acid.

ethanoic acid is a weak / weaker acid
it = ethanoic acid

(2)

Ethanol and ethanoic acid react in the presence of a catalyst to form an ester.

- (i) Name the ester made from ethanol and ethanoic acid.

ethyl ethanoate

(1)

- (ii) What type of chemical is used as a catalyst in this reaction?

acid

allow any strong acid

allow correct formulae

(1)

- (iii) Esters are used in perfumes because they smell pleasant and are volatile.

What does volatile mean?

evaporates easily / quickly
allow low boiling point
do **not** allow flammable

(1)

This question is about reversible reactions and chemical equilibrium.

(a) Reversible reactions can reach equilibrium in a closed system.

(i) What is meant by a closed system?

nothing can enter **and** nothing can leave the reaction
allow sealed reaction vessel

(1)

(ii) Explain why, when a reversible reaction reaches equilibrium, the reaction appears to have stopped.

forward and backward reactions have same rate

1

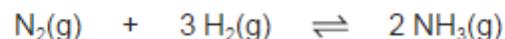
so there is no (overall) change in quantities of reactants and products

allow concentrations of reactants and products

1

(2)

(b) In the Haber process, the reaction of nitrogen with hydrogen to produce ammonia is reversible.



(i) Name a natural resource from which hydrogen is produced.

natural gas

allow methane / CH₄

allow fossil fuels / hydrocarbons

allow water

(1)

(ii) The Haber process uses a catalyst to speed up the reaction.

Explain how a catalyst speeds up a reaction.

provides an alternative reaction pathway

which has a lower activation energy

ignore references to collisions

(2)

(iii) What happens to the amount of ammonia produced at equilibrium if the pressure is increased?

Give a reason for your answer.

the amount (of ammonia) increases

allow yield increases

1

the equilibrium moves to the side (of the equation) with fewer (gaseous) molecules / moles

allow it favours the forward reaction

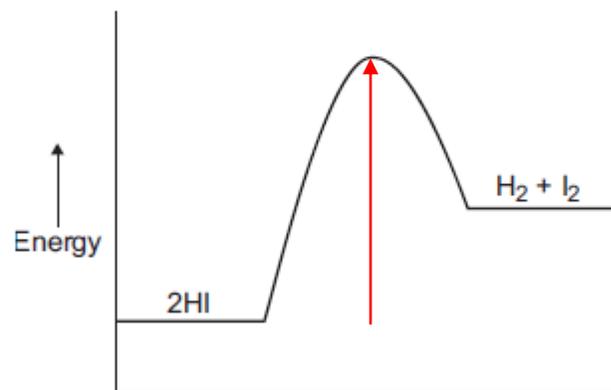
1

(c) The decomposition of hydrogen iodide into hydrogen and iodine is reversible.



The forward reaction is endothermic.

The energy level diagram shown below is for the forward reaction.



(i) Draw an arrow to show the activation energy on the diagram.

vertical arrow from reactants to maximum

(ii) How does the diagram show that the reaction is endothermic?

(energy of) products higher than (energy of) reactants
allow converse

(1)

(iii) Suggest what effect, if any, increasing the temperature will have on the amount of hydrogen iodide at equilibrium.

Give a reason for your answer.

amount of hydrogen iodide decreases

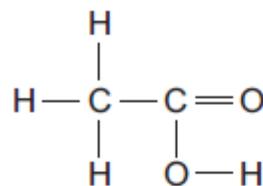
equilibrium moves in the direction of the endothermic reaction
allow it favours the forward reaction

(2)

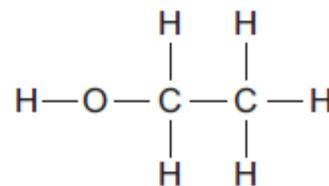
(1)

The diagrams represent two compounds, **A** and **B**.

Compound A



Compound B



(a) (i) Compound **B** is an alcohol.

Name compound **B**.

ethanol

(1)

(ii) Use the correct answer from the box to complete the sentence.

burned decomposed oxidised

To form compound **A**,

compound **B** is

oxidised

(1)

(iii) Compounds **A** and **B** are both colourless liquids.

A test tube contains a colourless liquid, which could be either compound **A** or compound **B**.

Describe a simple **chemical** test to show which compound, **A** or **B**, is in the test tube.

.....
.....
.....

(iii) **Test**

add any named carbonate or hydrogen carbonate
*the first mark is for the test; the second is for the result
if the test is incorrect award 0 marks.*

Result

A will effervesce (carbon dioxide) **or** **B** will not effervesce.
if the result is incorrect, award the first mark only

or

candidates do not have to name a gas but penalise an incorrect gas.

Test

add a named (magnesium, aluminium, zinc, iron or tin) metal
give credit to any test that will work.

Result

A will effervesce (hydrogen), **B** will not
allow a test that would identify B.

or

Test

add an acid-base indicator

Result

credit any acid colour for that indicator eg for universal indicator allow red, yellow or orange

give credit for the neutral colour for **B**

or

Test

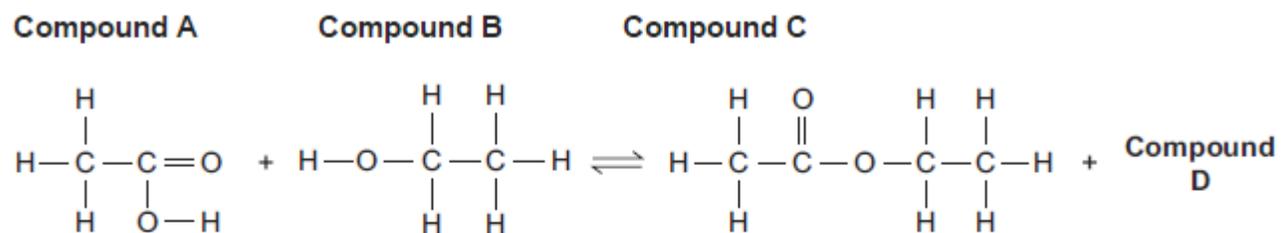
add an alcohol (+ acid catalyst)

Result

sweet or fruity smell of esters.

(2)

(b) Compounds **A** and **B** react to produce compound **C** and compound **D**.



(i) What is the formula of compound **D**?

H₂O

(1)

(ii) Compound **C** is an ester.

Name compound **C**.

ethyl ethanoate

(1)

(iii) State **one** use of esters.

any **one** from:

- flavourings
- perfumes
- solvents
- plasticisers

allow any correct use of esters

(1)

The equation for the reaction of ethene and bromine is:

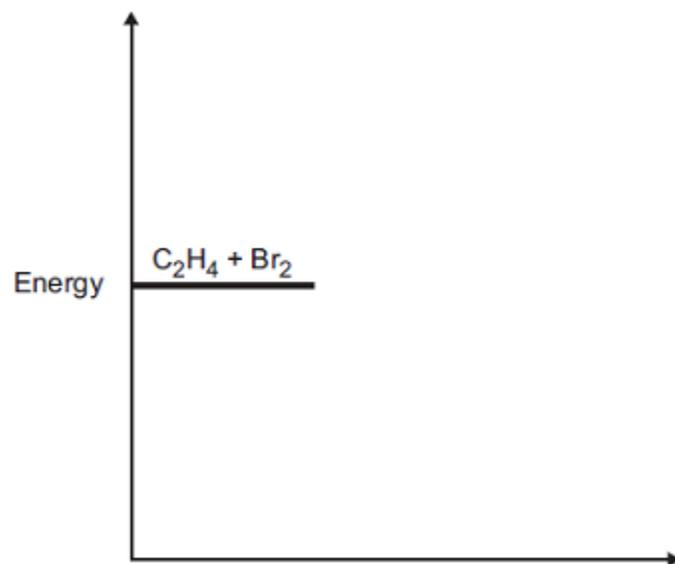


The reaction is exothermic.

(a) Complete the energy level diagram.

You should label:

- the activation energy
- the enthalpy change (ΔH).



products are at a lower energy level than reactants

if candidate has drawn a profile for an endothermic reaction penalise first marking point only

1

activation energy correctly drawn and labelled

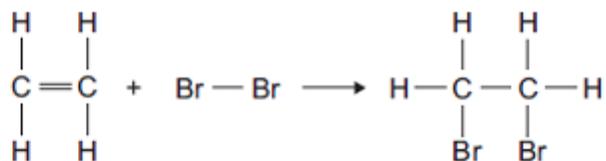
1

ΔH correctly labelled

1

(3)

(b) (i) The equation for the reaction can be represented as:



Bond	Bond dissociation energy in kJ per mole
C—H	413
C = C	614
Br—Br	193
C—C	348
C—Br	276

Use the bond dissociation energies in the table to calculate the enthalpy change (ΔH) for this reaction.

–93 (kJ per mole)

correct answer with or without working gains 3 marks

allow 2 marks for +93 kJ per mole

if any other answer is seen award up to 2 marks for any two of the steps below:

bonds broken (614 + 193) = 807 (kJ) or (614 + 193 + (4 × 413)) = 2459(kJ)

bonds formed (348 + 276 + 276) = 900(kJ) or 348 + (2 × 276) + (4 × 413) = 2552(kJ)

bonds broken – bonds formed

allow ecf for arithmetical errors

(ii) The reaction is exothermic.

Explain why, in terms of bonds broken and bonds formed.

more energy is released when the bonds (in the products) are formed

1

than is needed to break the bonds (in the reactants)

*if no other marks gained, allow 1 mark for energy released for bond making **and** energy used for bond breaking*

1

(2)

(3)

Ethanoic acid is a *weak* acid.

Draw a ring around the correct answer to complete each sentence.

(i) When dissolved in water, an acid forms a solution containing

(a) (i) hydrogen ions

1

(ii) partially ionised

1

hydroxide ions

(1)

(ii) Ethanoic acid is a *weak* acid because in water it is

completely ionised.

not ionised.

partially ionised.

(ii) Phenolphthalein is added to the vinegar in the conical flask so that the end point of the titration can be seen.

What type of substance is phenolphthalein?

Draw a ring around the correct answer.

alkali

catalyst

indicator

(1)



- (a) (i) Complete the diagram for propanol, the next member of the homologous series.



(a) (i) 7 C-H bonds and 1 C-O-H bond

1

(1)

(ii) Which **one** of the statements about ethanol is correct?

Tick (✓) **one** box.

Statement	Tick (✓)
Ethanol dissolves in water to form a neutral solution	
Ethanol reacts with oxygen by (b) (i) oxidation	1
Ethanol does not burn in air.	1

(1)

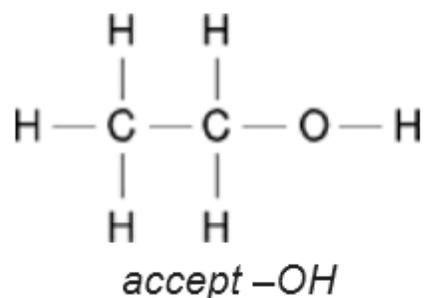
Ethanoic acid (CH_3COOH) can be produced from ethanol ($\text{CH}_3\text{CH}_2\text{OH}$).

(i) What type of reaction happens when ethanoic acid is produced from ethanol?

(a) Ethanol is an alcohol. The structural formula of ethanol is $\text{CH}_3\text{CH}_2\text{OH}$.

(i) Draw the displayed structure of ethanol, showing all the bonds.

(a) (i) correct structure showing all bonds



- (b) (i) The structural formula of ethanoic acid is CH_3COOH .

Dilute solutions of ethanol can be converted into dilute solutions of ethanoic acid.

Use a word from the box to complete the sentence.

neutralised

oxidised

reduced

In this
is

(b) (i) oxidised

1

(ii) vinegar

1

(1)

- (ii) What is the common name for a dilute solution of ethanoic acid?