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CHEMISTRY**0620/31**

Paper 3 Theory (Core)

October/November 2025**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **20** pages.

1 Fig. 1.1 shows part of the Periodic Table.

I	II											III	IV	V	VI	VII	VIII	
																		He
Li													C	N			Ne	
	Mg											Al	Si		S	Cl		
K			Ti				Fe			Cu	Zn							
															I			

Fig. 1.1

Answer the following questions using only the symbols of the elements in Fig. 1.1.
Each symbol may be used once, more than once or not at all.

Give the symbol of the element that:

- (a) forms an ion which produces a red colour in a flame test

..... [1]

- (b) is present in diamond

..... [1]

- (c) forms an ion with a charge of 2–

..... [1]

- (d) is extracted from bauxite

..... [1]

- (e) is used in electrical wiring because of its good electrical conductivity and ductility.

..... [1]

[Total: 5]



2 The symbol for an atom of argon is shown.



(a) Complete Table 2.1 to show the number of protons and neutrons in one atom of ${}_{18}^{40}\text{Ar}$.

Table 2.1

number of protons	
number of neutrons	

[2]

(b) Argon is an unreactive monatomic element.

(i) Explain what is meant by the term monatomic.

..... [1]

(ii) Explain why argon is unreactive. Give your answer in terms of electronic configuration.

..... [1]

(c) At room temperature and pressure, argon is a gas.

A sample of argon is placed in a sealed syringe with a freely moving plunger.

Complete Table 2.2 to show the effect, if any, on the volume of argon when:

- the temperature of the argon is increased
- the pressure of the argon is increased.

Use the words **increases**, **decreases** or **no change** in your answer.

Table 2.2

change	effect on the volume of argon
temperature is increased	
pressure is increased	

[2]

[Total: 6]



- 3 (a) Table 3.1 shows the masses of ions, in mg, present in a 1000 cm^3 sample of river water.

Table 3.1

name of ion	formula of ion	mass of ion in 1000 cm^3 of river water / mg
ammonium	NH_4^+	0.5
bromide	Br^-	0.2
calcium	Ca^{2+}	1.4
hydrogencarbonate	HCO_3^-	6.0
iodide	I^-	3.2
lithium	Li^+	4.3
nitrate	NO_3^-	9.5
phosphate	PO_4^{3-}	0.7
sodium	Na^+	8.3
sulfate		0.9

Answer these questions using the information from Table 3.1.

- (i) Name the positive ion that has the highest concentration.

..... [1]

- (ii) State the formula of the sulfate ion.

..... [1]

- (iii) Describe a test to identify the presence of iodide ions, I^- , in a sample of water.

test

.....

observations

[2]

- (iv) Calculate the mass of nitrate ions, NO_3^- , in 200 cm^3 of river water.

mass = ... mg [1]



- (b) Give the formulae of **two** ions from Table 3.1 which can be combined with potassium ions to make an NPK fertiliser.

..... and [1]

- (c) Name **two** ions from Table 3.1 which lead to deoxygenation of water and damage to aquatic life.

..... and [2]

- (d) The diagram in Fig. 3.1 shows the apparatus used to separate pure water from the sample of river water.

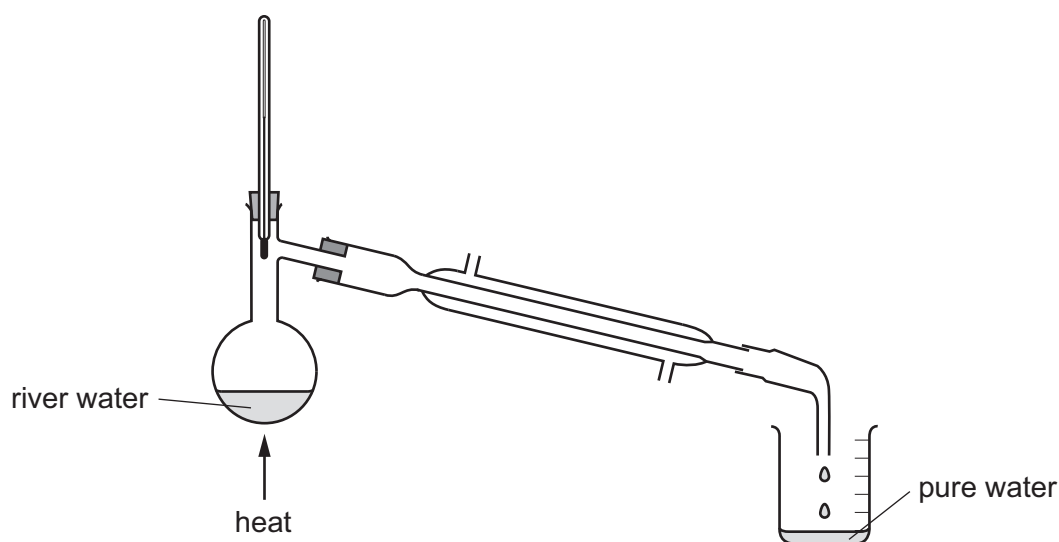


Fig. 3.1

Name the separation method shown in Fig. 3.1.

..... [1]

[Total: 9]



- 4 (a) Molecules of compound **C** are produced by some plants.

Fig. 4.1 shows the displayed formula of a molecule of compound **C**.

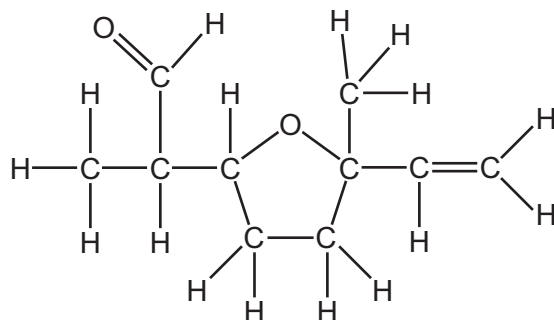


Fig. 4.1

Deduce the molecular formula of compound **C** to show the number of atoms of carbon, hydrogen and oxygen.

..... [1]

- (b) On Fig. 4.1, draw a circle around the part of the molecule which shows that the molecule is unsaturated. [1]

- (c) A different molecule found in plants has the molecular formula $C_{11}H_{14}O_3$.

Complete Table 4.1 to calculate the relative molecular mass of $C_{11}H_{14}O_3$.

Table 4.1

type of atom	number of atoms	relative atomic mass	
carbon	11	12	$11 \times 12 = 132$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

- (d) Petroleum is a mixture of hydrocarbons which can be separated into groups of compounds called fractions.

Explain what is meant by the term hydrocarbon.

..... [1]



- (e) Fig. 4.2 shows the names of some of the fractions obtained from petroleum using a fractionating column.

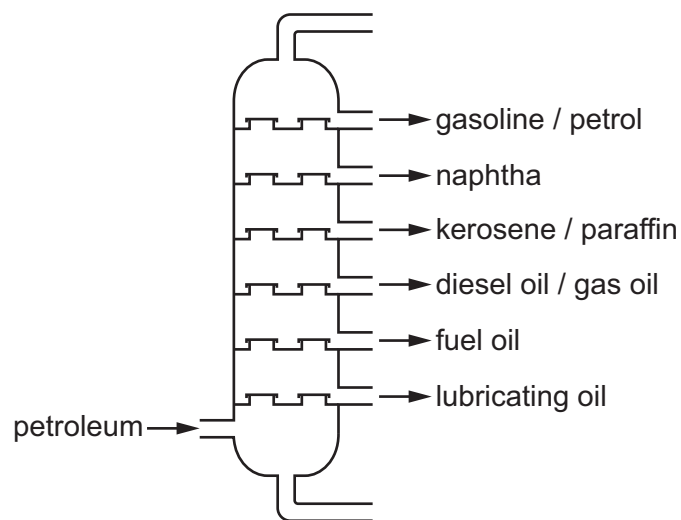


Fig. 4.2

Using only the fractions shown in Fig. 4.2, name the fraction which contains compounds that:

- (i) have the lowest boiling point

..... [1]

- (ii) have the highest viscosity

..... [1]

- (iii) are used for jet fuel.

..... [1]



(f) Table 4.2 shows some properties of compounds found in the naphtha fraction.

Table 4.2

name	molecular formula	melting point / °C	boiling point / °C
heptane		−90	98
octane	C ₈ H ₁₈		125
nonane	C ₉ H ₂₀	−54	150
decane	C ₁₀ H ₂₂	−30	174
undecane	C ₁₁ H ₂₄	−25	195

(i) A molecule of heptane contains seven carbon atoms.

Deduce the molecular formula of heptane.

..... [1]

(ii) Use the information in Table 4.2 to predict the melting point of octane, C₈H₁₈.

..... [1]

(g) When heated strongly in the presence of a catalyst, decane reacts to form smaller molecules.

(i) Name this type of endothermic reaction.

..... [1]

(ii) Ethene is one of the molecules formed when decane is heated strongly in the presence of a catalyst.

Draw the displayed formula of ethene. Show all the atoms and all the bonds.

[2]



(h) Ethene is polymerised to form the plastic poly(ethene).

(i) Name this type of polymerisation.

..... [1]

(ii) Describe **two** environmental challenges caused by the disposal of plastics such as poly(ethene).

1

.....

2

.....

[2]

[Total: 16]



- 5 This question is about elements in Group I and in Group VII of the Periodic Table and their compounds.

(a) Chlorine is in Group VII of the Periodic Table.

Give the colour and state of chlorine at room temperature and pressure.

colour

state

[2]

(b) State the use of chlorine in the treatment of the domestic water supply.

..... [1]

(c) Iodine is in Group VII of the Periodic Table.

Table 5.1 shows the melting point and the boiling point of iodine.

Table 5.1

melting point/°C	114
boiling point/°C	184

Use the information in Table 5.1 to deduce the physical state of iodine at 195 °C.

Give a reason for your answer.

physical state

reason

[2]

(d) Potassium is an element in Group I of the Periodic Table.

Elements in Group I have a low density and relatively low melting and boiling points.

State **one other** physical property of potassium.

..... [1]



(e) When a sample of potassium is added to a large container of cold water, a chemical reaction occurs.

(i) Describe what is observed when potassium is added to water.

.....

.....

.....

.....

.....

..... [3]

(ii) The word equation for the reaction of potassium with water is shown.

potassium + water → potassium hydroxide + hydrogen

Describe a test for hydrogen.

test

observations

[1]

(f) Potassium reacts with oxygen to form potassium oxide, K_2O .

Complete the symbol equation for this reaction.

..... K + ... → $2K_2O$

[2]

(g) Solid potassium oxide, K_2O , dissolves in water to form an alkali.

Choose the pH value of the solution formed when solid potassium oxide is dissolved in water.

Draw a circle around your chosen answer.

pH 1

pH 5

pH 7

pH 12

[1]



(h) Potassium reacts with chlorine to form the ionic compound potassium chloride.

Complete the dot-and-cross diagram in Fig. 5.1 for potassium chloride to show:

- the electronic configuration for each ion
- the charge on each ion.

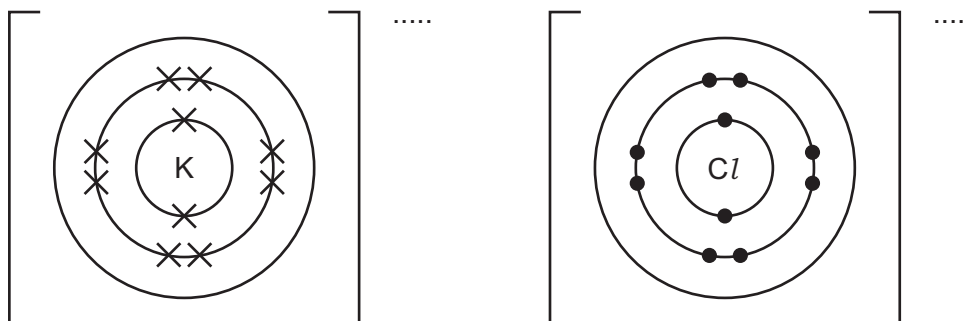


Fig. 5.1

[3]

[Total: 16]





Question 6 starts on the next page.



6 This question is about metals.

(a) Iron is extracted from its ore using carbon (coke) and calcium carbonate in a blast furnace.

(i) Give **two** reasons why carbon is used in a blast furnace.

1

2 [2]

(ii) Slag is a waste product of this extraction.

Describe how slag is produced.

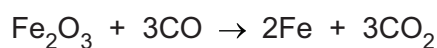
.....

.....

..... [2]

(iii) Iron ore contains iron(III) oxide.

The equation for the extraction of iron from iron(III) oxide is shown.



Explain how this equation shows that carbon monoxide is oxidised.

..... [1]

(b) Pure iron is less useful than its alloys such as stainless steel.

(i) Name **two** metals most commonly used in stainless steel, other than iron.

1

2 [2]

(ii) State **one** use of stainless steel.

..... [1]



- (c) Table 6.1 shows the observations when four different metals are added separately to dilute ethanoic acid.

Table 6.1

metal	observations
zinc	a few bubbles of gas given off slowly and the temperature of the mixture increases very slowly
titanium	no bubbles of gas given off and no temperature increase of the mixture
calcium	many bubbles of gas given off very quickly and the temperature of the mixture increases rapidly
magnesium	bubbles of gas given off quickly and the temperature of the mixture increases slowly

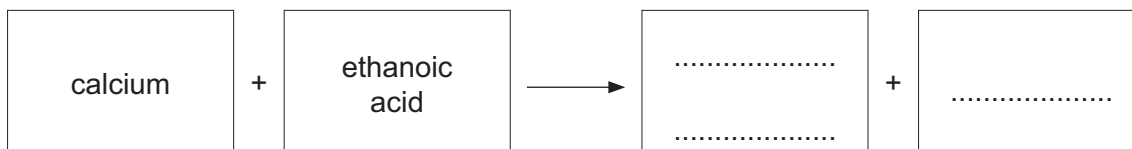
- (i) Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive $\longrightarrow$ most reactive

--	--	--	--

[2]

- (ii) Complete the word equation for the reaction of calcium with ethanoic acid.



[2]

[Total: 12]



- 7 Fig. 7.1 shows the apparatus used to electrolyse dilute sulfuric acid using inert electrodes.

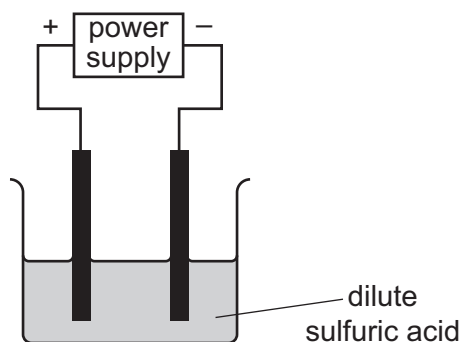


Fig. 7.1

- (a) State what is meant by the term electrolysis.

.....
..... [2]

- (b) Label the cathode in Fig. 7.1.

[1]

- (c) Name **one** product formed at the anode.

..... [1]

- (d) The inert electrodes used are made of graphite.

- (i) Explain what is meant by the term inert.

..... [1]

- (ii) State **one other** use for graphite.

..... [1]



- (e) Excess solid copper(II) carbonate is added to dilute sulfuric acid.
Aqueous copper(II) sulfate, water and carbon dioxide gas are produced.

(i) State with a reason if this is a chemical or a physical change.

.....
..... [1]

(ii) Name a method to remove the excess copper(II) carbonate from the mixture.

..... [1]

(iii) Name **one other** substance which can be added to dilute sulfuric acid to form aqueous copper(II) sulfate.

..... [1]

(f) Copper(II) sulfate, CuSO_4 , exists in different forms.

Draw **one** line from each form of copper(II) sulfate to its description.

form of copper(II) sulfate	description
aqueous CuSO_4	solid CuSO_4 chemically combined with water
hydrated CuSO_4	CuSO_4 dissolved in water
anhydrous CuSO_4	solid CuSO_4 containing no water

[2]

[Total: 11]



- 8 A student investigates the reaction of small pieces of magnesium with excess dilute hydrochloric acid.

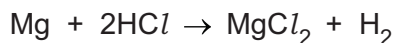


Fig. 8.1 shows the total volume of hydrogen gas, H_2 , produced as the reaction proceeds.

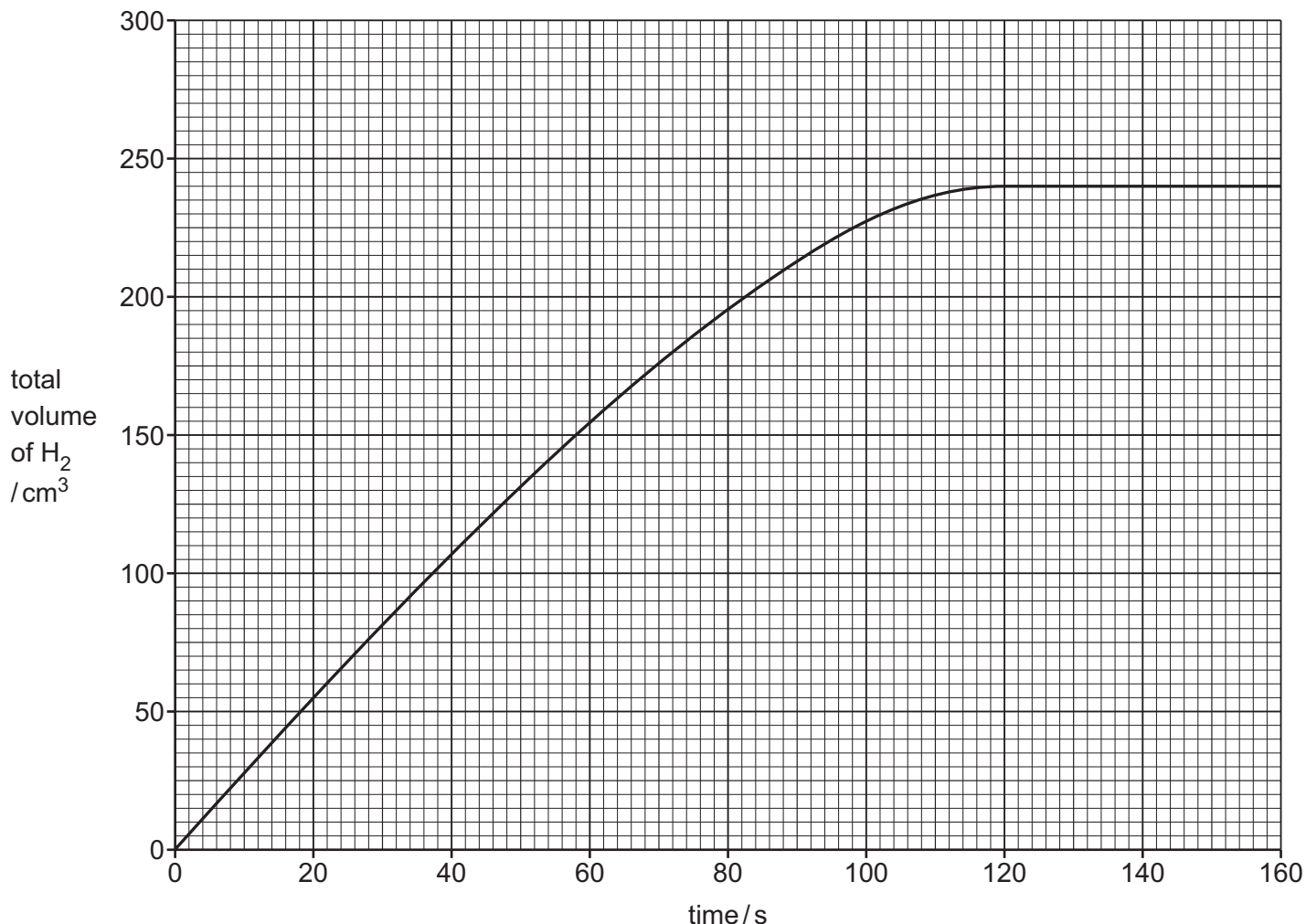


Fig. 8.1

- (a) Use Fig. 8.1 to deduce the time taken for the reaction to finish.

time taken for reaction to finish = ... s [1]

- (b) The reaction is repeated using larger pieces of magnesium of the same total mass.

All other conditions stay the same.

State the effect, if any, on:

- (i) the time taken for the reaction to finish

..... [1]

- (ii) the total volume of H_2 produced when the reaction is complete.

..... [1]



- (c) Fig. 8.2 shows the reaction pathway diagram for the reaction of magnesium with dilute hydrochloric acid.

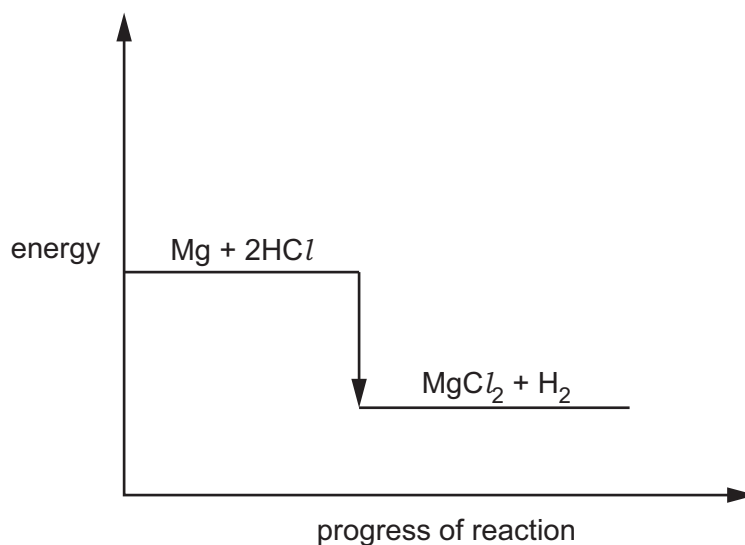


Fig. 8.2

Deduce the type of energy change shown in the diagram in Fig. 8.2.

Explain your answer.

.....

.....

.....

..... [2]

[Total: 5]

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The Periodic Table of Elements

Group																			
I	II											III	IV	V	VI	VII	VIII		
3 Li lithium 7	4 Be beryllium 9	Key atomic number atomic symbol name relative atomic mass										1 H hydrogen 1						2 He helium 4	
11 Na sodium 23	12 Mg magnesium 24											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20		
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium —	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131	55 Kr krypton 84	56 Ba barium 137
55 Cs caesium 133	56 La lanthanoids	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —	85 At astatine —	86 Rn radon —	87 Fr francium —	88 Ra radium —
87 Fr francium —	88 La actinoids	89–103 actinoids	104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	113 Nh nihonium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	117 Ts tennessine —	118 Og oganeson —	119 Lu lutetium 175	120 Yb ytterbium 173

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).



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CHEMISTRY

0620/32

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October/November 2025

1 hour 15 minutes

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INFORMATION

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This document has **20** pages. Any blank pages are indicated.

1 Fig. 1.1 shows part of the Periodic Table.

I II												III	IV	V	VI	VII	VIII
																	He
												B	C	N	O		Ne
Na																Cl	
K	Ca						Fe				Zn					Br	
										Ag						I	

Fig. 1.1

Answer the following questions using only the symbols of the elements in Fig. 1.1.
Each symbol may be used once, more than once or not at all.

Give the symbol of the element that:

(a) is used as a lubricant

..... [1]

(b) forms an ion which is present in every dilute acid

..... [1]

(c) is a metal which does **not** react with steam

..... [1]

(d) is in Period 3 and forms an ion with a charge of 1– when it reacts.

..... [1]

[Total: 4]



2 The symbol for an atom of krypton is shown.



(a) Complete Table 2.1 to show the number of electrons and neutrons in one atom of ${}_{36}^{84}\text{Kr}$.

Table 2.1

number of electrons	
number of neutrons	

[2]

(b) Krypton is a gas at room temperature and pressure.

A sample of krypton is placed in a sealed syringe with a freely moving plunger.

Complete Table 2.2 to show the effect, if any, on the volume of krypton when:

- the temperature of the krypton is decreased
- the pressure of the krypton is increased.

Use the words **increases**, **decreases** or **no change** in your answer.

Table 2.2

change	effect on the volume of krypton
temperature is decreased	
pressure is increased	

[2]

(c) When krypton is cooled, it becomes a liquid.

Describe the arrangement of the particles in liquid krypton.
Give your answer in terms of particle separation and motion.

particle separation

.....

particle motion

.....

[2]

[Total: 6]



- 3 (a) Table 3.1 shows the masses of ions, in mg, present in a 500 cm^3 sample of contaminated water.

Table 3.1

name of ion	formula of ion	mass of ion in 500 cm^3 of contaminated water /mg
ammonium		2.5
chloride	Cl^-	4.2
hydrogencarbonate	HCO_3^-	6.0
iodide	I^-	0.4
lithium	Li^+	4.3
magnesium	Mg^{2+}	0.8
nitrate	NO_3^-	8.5
phosphate	PO_4^{3-}	0.7
potassium	K^+	9.3
sulfate	SO_4^{2-}	0.3

Answer these questions using the information from Table 3.1.

- (i) Name the negative ion that has the highest concentration.

..... [1]

- (ii) State the formula of the ammonium ion.

..... [1]

- (iii) Describe a test to identify the presence of chloride ions, Cl^- , in a sample of water.

test

observations

..... [2]

- (iv) Calculate the mass of hydrogencarbonate ions, HCO_3^- , in 200 cm^3 of the contaminated water.

mass = ... mg [1]



- (b) The water sample is **not** suitable for use in practical chemistry.

Name a process that makes the water suitable for use in practical chemistry.

..... [1]

- (c) Water extracted from a river is made suitable for drinking by filtration and then treatment with carbon followed by chlorination.

- (i) State why carbon is used in the treatment of water.

..... [1]

- (ii) State why water is chlorinated.

..... [1]

- (d) Fig. 3.1 shows the apparatus used to analyse a sample of water containing coloured substances and the results obtained.

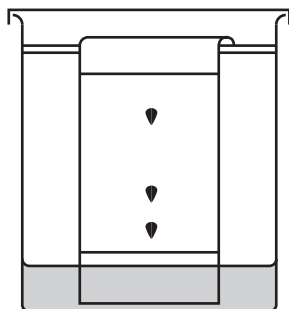


Fig. 3.1

- (i) Name the separation method shown in Fig. 3.1.

..... [1]

- (ii) Label the solvent front in Fig. 3.1.

[1]

[Total: 10]





- 4 (a) Molecules of compound **A** are found in some plants.

Fig. 4.1 shows the displayed formula of a molecule of compound **A**.

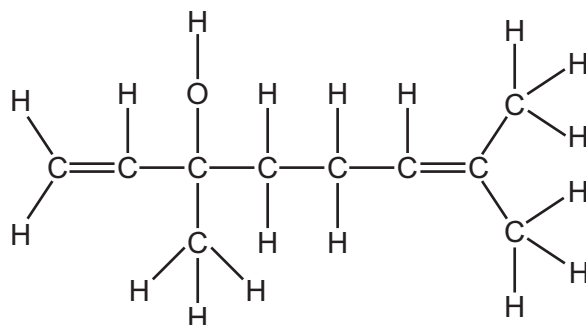


Fig. 4.1

Deduce the molecular formula of compound **A** to show the number of atoms of carbon, hydrogen and oxygen.

..... [1]

- (b) On Fig. 4.1, draw a circle around **one** part of the molecule responsible for the decolourisation of aqueous bromine. [1]

- (c) A different molecule found in plants has the molecular formula $C_{10}H_{16}O_2$.

Complete Table 4.1 to calculate the relative molecular mass of $C_{10}H_{16}O_2$.

Table 4.1

type of atom	number of atoms	relative atomic mass	
carbon	10	12	$10 \times 12 = 120$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]



(d) Petroleum is a fossil fuel.

Name **one other** fossil fuel.

..... [1]

(e) Fig. 4.2 shows the names of some of the fractions obtained from petroleum using a fractionating column.

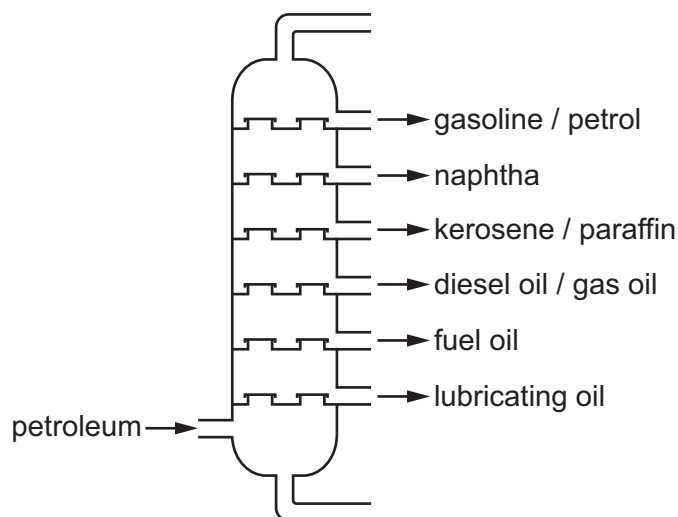


Fig. 4.2

Using only the fractions shown in Fig. 4.2, name the fraction which contains compounds that:

(i) have the longest chain length

..... [1]

(ii) have the highest volatility

..... [1]

(iii) are used for home heating systems.

..... [1]

(f) Table 4.2 shows some properties of hydrocarbons found in fuel for jet engines.

Table 4.2

name	molecular formula	melting point / °C	boiling point / °C
nonene	C_9H_{18}	-81	147
decane	$C_{10}H_{22}$	-30	174
undecane	$C_{11}H_{24}$	-26	195
dodecane	$C_{12}H_{26}$	-10	216
tridecane	$C_{13}H_{28}$	-5	234



- (i) Identify the unsaturated hydrocarbon in Table 4.2.

..... [1]

- (ii) Explain your answer in (f)(i).

.....

..... [1]

- (g) (i) In excess oxygen, decane undergoes complete combustion to produce carbon dioxide and one other product.

Identify this other product.

..... [1]

- (ii) State **one** adverse effect to the environment of the production of carbon dioxide.

.....

..... [1]

- (h) (i) Ethanol can be used to make jet fuel.

Draw the displayed formula of ethanol. Show all the atoms and all the bonds.

[2]

- (ii) Ethanol can be manufactured from ethene and one other reactant.

Name the other reactant, and state the temperature and pressure used.

reactant

temperature °C

pressure atm

[3]

[Total: 17]



5 This question is about elements in different groups of the Periodic Table and their compounds.

(a) Nitrogen is in Group V of the Periodic Table.

Explain why nitrogen is placed in Group V.
Give your answer in terms of electronic configuration.

..... [1]

(b) Tellurium is in Group VI of the Periodic Table.

Table 5.1 shows the melting point and the boiling point of tellurium.

Table 5.1

melting point/°C	450
boiling point/°C	988

Use Table 5.1 to deduce the physical state of tellurium at 650 °C.

Give a reason for your answer.

physical state

reason

..... [2]

(c) Bromine is in Group VII of the Periodic Table.

Give the colour and state of bromine at room temperature and pressure.

colour

state

[2]

(d) When a sample of sodium is added to a large container of cold water, a chemical reaction occurs.

(i) Describe what is observed when sodium is added to water.

.....

.....

.....

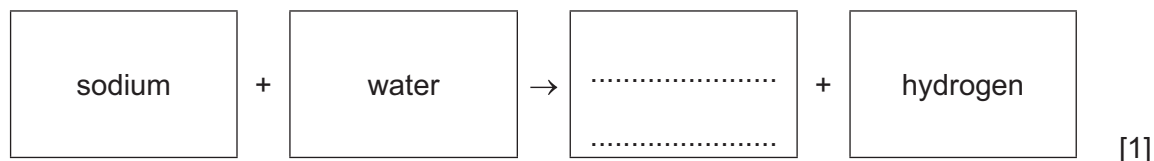
.....

.....

..... [3]

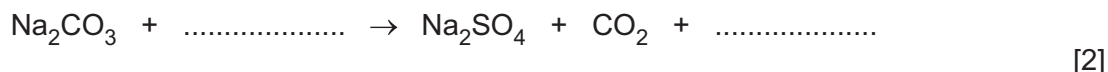


(ii) Complete the word equation for the reaction of sodium with water.



(e) Sodium carbonate reacts with sulfuric acid to form sodium sulfate, carbon dioxide and one other product.

Complete the symbol equation for this reaction.



(f) Solid sodium hydroxide is slowly added to distilled water containing a few drops of thymolphthalein and the mixture is stirred.

(i) State the colour change observed when sodium hydroxide is added to water containing thymolphthalein.

from to [2]

(ii) Aqueous sodium hydroxide is an alkali.

Complete the sentence about an alkali using **one** of the words from the list.

acid base indicator salt

An alkali is a soluble [1]

(g) Fluorine is in Group VII of the Periodic Table. Fluorine reacts with sodium to form the ionic compound sodium fluoride.

Complete the dot-and-cross diagram in Fig. 5.1 for sodium fluoride to show:

- the electronic configuration for each ion
- the charge on each ion.

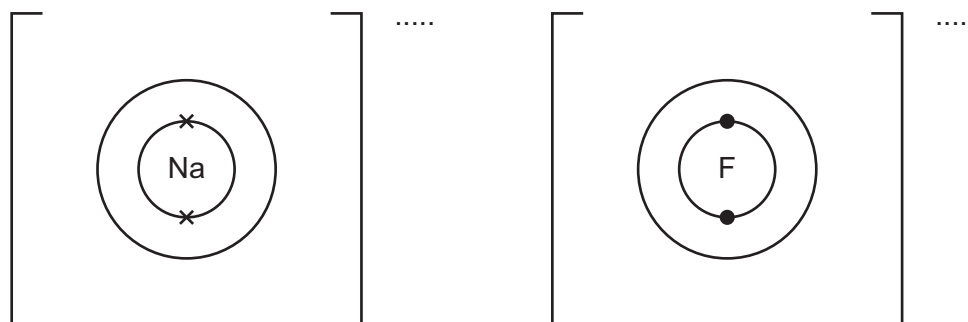


Fig. 5.1

[3]

[Total: 17]



6 This question is about metals.

- (a) Iron is extracted from its ore using carbon in a blast furnace.
Aluminium is extracted from its ore using electrolysis.

(i) Name the main ore of aluminium.

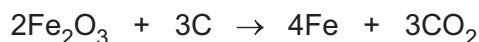
..... [1]

- (ii) Explain why aluminium is **not** extracted from its ore by reduction with carbon.
Give your answer in terms of the reactivity series.

.....

..... [1]

- (iii) An equation for the reduction of iron(III) oxide using carbon is shown.



Explain how this equation shows that iron(III) oxide is reduced.

.....

..... [1]

- (b) Iron is made into stainless steel. Stainless steel is an alloy that resists rusting.

(i) State what is meant by the term alloy.

.....

..... [2]

- (ii) Name the **two** substances required for iron to rust.

..... and [2]

- (iii) State the chemical name for rust.

..... [2]



- (c) Table 6.1 shows the observations when four different metals are added separately to dilute hydrochloric acid.

Table 6.1

metal	observations
Mn	bubbles of gas given off quickly and the temperature of the mixture increases slowly
Fe	a few bubbles of gas given off very slowly and the temperature of the mixture increases very slowly
Sr	many bubbles of gas given off very quickly and the temperature of the mixture increases rapidly
Nb	no bubbles of gas given off and no temperature increase of the mixture

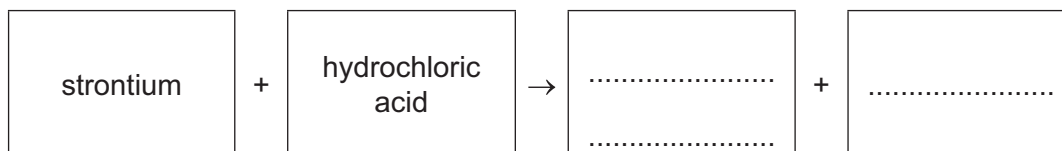
- (i) Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive $\longrightarrow$ most reactive

--	--	--	--

[2]

- (ii) Complete the word equation for the reaction of strontium with hydrochloric acid.



[2]

[Total: 13]



- 7 Fig. 7.1 shows the apparatus used to pass electricity through molten magnesium chloride using platinum electrodes.

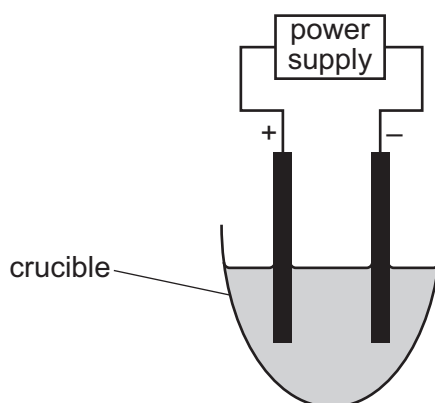


Fig. 7.1

- (a) Name the process shown in Fig. 7.1.

..... [1]

- (b) Label the electrolyte in Fig. 7.1.

[1]

- (c) Name the product formed at the anode.

..... [1]

- (d) The electrodes are made of platinum.

- (i) State **one** property of platinum that makes it suitable for use as an electrode.

..... [1]

- (ii) Suggest a non-metal that could be used as the electrodes.

..... [1]

- (e) State whether the process shown in Fig. 7.1 produces a physical or chemical change.

Explain your answer.

type of change

explanation

..... [1]



(f) Magnesium chloride, MgCl_2 , exists in different forms.

Draw **one** line from each form of magnesium chloride to its description.

form of magnesium chloride

aqueous MgCl_2

anhydrous MgCl_2

hydrated MgCl_2

description

solid MgCl_2 chemically
combined with water

MgCl_2 dissolved in water

solid MgCl_2 containing
no water

[2]

[Total: 8]



- 8 Excess dilute hydrochloric acid is added to aqueous sodium sulfide to form aqueous sodium chloride and gaseous hydrogen sulfide, H_2S .

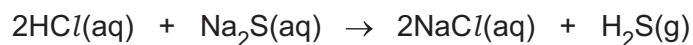


Fig. 8.1 shows the total volume of hydrogen sulfide gas, H_2S , produced as the reaction proceeds.

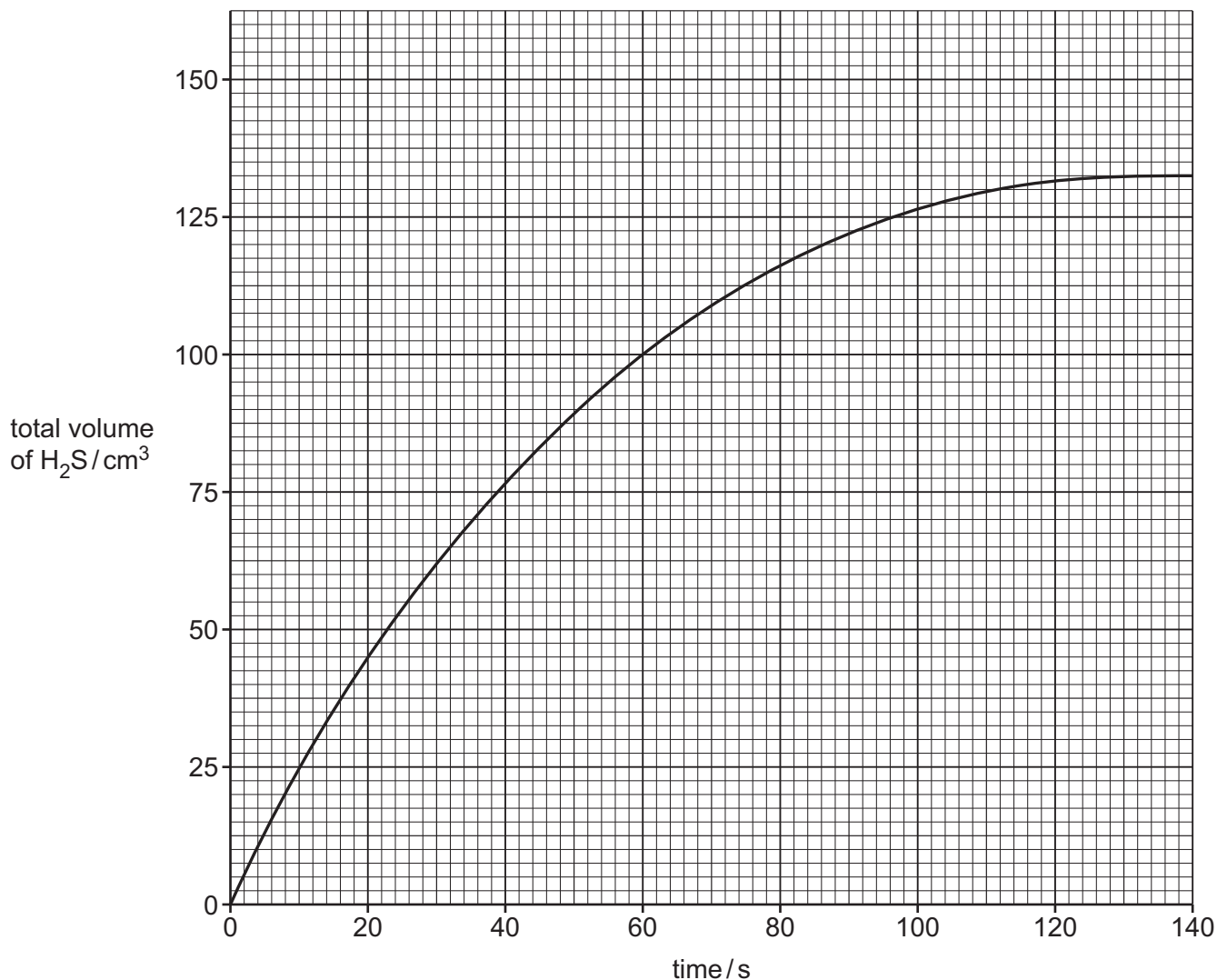


Fig. 8.1

- (a) Use Fig. 8.1 to determine the total volume of H_2S produced when the reaction is complete.

total volume of H_2S = ... cm^3 [1]



- (b) The reaction is repeated using hydrochloric acid of a higher concentration.

All other conditions stay the same.

State the effect, if any, on:

- (i) the time taken for the reaction to finish

..... [1]

- (ii) the total volume of H_2S produced when the reaction is complete.

..... [1]

- (c) Fig. 8.2 shows the reaction pathway diagram for the reaction of dilute hydrochloric acid with aqueous sodium sulfide.

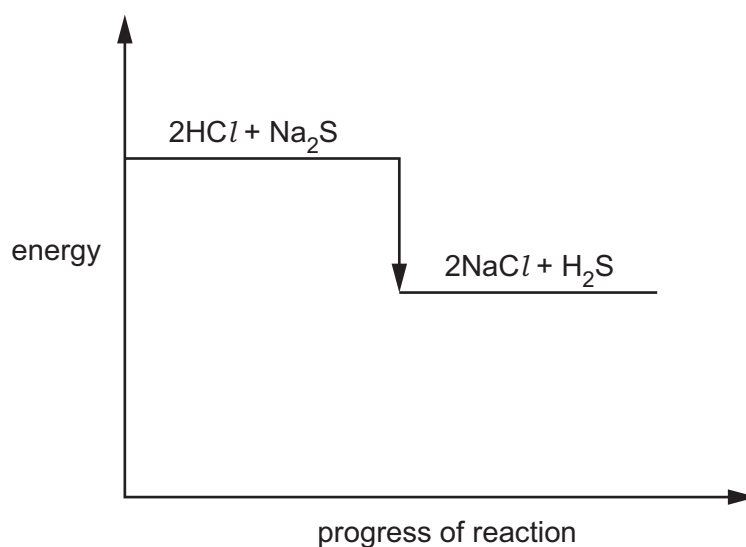


Fig. 8.2

Deduce the type of energy change shown in the diagram in Fig. 8.2.

Explain your answer.

.....

 [2]

[Total: 5]





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The Periodic Table of Elements

Group																		
I	II											III	IV	V	VI	VII	VIII	
		Key atomic number atomic symbol name relative atomic mass																
3 Li lithium 7	4 Be beryllium 9																	
11 Na sodium 23	12 Mg magnesium 24	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40											10 Ne neon 20
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84	
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium —	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131	
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids		72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —	85 At astatine —	86 Rn radon —
87 Fr francium —	88 Ra radium —	89–103 actinoids		104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	113 Nh nihonium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	117 Ts tennessine —	118 Og oganesson —

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium —	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
	89 Ac actinium —	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).





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CHEMISTRY

0620/33

Paper 3 Theory (Core)

October/November 2025

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **20** pages.

1 Fig. 1.1 shows part of the Periodic Table.

I		II												III	IV	V	VI	VII	VIII	
																				He
Li													C	N	O			Ne		
Na												Al			S					
	Ca						Fe				Zn					Br				
																I				
										Au										

Fig. 1.1

Answer the following questions using only the symbols of the elements in Fig. 1.1.
Each symbol may be used once, more than once or not at all.

Give the symbol of the element that:

- (a) is used in food containers because of its resistance to corrosion

..... [1]

- (b) is a metal that does **not** react with water, dilute acids or oxygen

..... [1]

- (c) reacts with hydrogen in a fuel cell

..... [1]

- (d) is bonded to hydrogen in methane.

..... [1]

[Total: 4]



2 The symbol for an atom of xenon is shown.



(a) Complete Table 2.1 to show the number of neutrons and nucleons in one atom of ${}_{54}^{131}\text{Xe}$.

Table 2.1

number of neutrons	
number of nucleons	

[2]

(b) Xenon is a gas at room temperature and pressure.

A sample of xenon is placed in a sealed syringe with a freely moving plunger.

Complete Table 2.2 to show the effect, if any, on the volume of xenon when:

- the temperature of the xenon is decreased
- the pressure of the xenon is decreased.

Use the words **increases**, **decreases** or **no change** in your answer.

Table 2.2

change	effect on the volume of xenon
temperature is decreased	
pressure is decreased	

[2]

(c) When xenon is cooled, it becomes a solid.

Describe the arrangement and motion of the particles in solid xenon.

particle arrangement

.....

particle motion

.....

[2]

[Total: 6]



- 3 (a) Table 3.1 shows the masses of ions, in mg, present in a 600 cm^3 sample of contaminated water.

Table 3.1

name of ion	formula of ion	mass of ion in 600 cm^3 of contaminated water / mg
calcium	Ca^{2+}	7.3
hydrogencarbonate	HCO_3^-	11.2
iodide	I^-	25.0
magnesium	Mg^{2+}	6.2
nitrate	NO_3^-	0.3
	PO_4^{3-}	0.1
potassium	K^+	0.1
sodium	Na^+	2.7
sulfate	SO_4^{2-}	9.0

Answer these questions using the information from Table 3.1.

- (i) Name the positive ion that has the highest concentration.

..... [1]

- (ii) State the name of the PO_4^{3-} ion.

..... [1]

- (iii) Describe a test to identify the presence of nitrate ions, NO_3^- , in a sample of water.

test

.....

test result

[2]

- (iv) Calculate the mass of sodium ions, Na^+ , in 200 cm^3 of the contaminated water.

mass = ... mg [1]

- (v) A higher concentration of nitrate ions in river water can cause deoxygenation.

State a source of a higher concentration of nitrate ions in river water.

..... [1]



- (b) A sample of water is taken from a river. The sample contains some insoluble substances.

State **one** method of removing the insoluble substances from the water.

..... [1]

- (c) (i) The water contains harmful microbes.

Suggest a source of the microbes in the water.

..... [1]

- (ii) State how the water is treated so that the microbes do **not** cause harm to people.

..... [1]

- (d) Before the treatment in (c)(ii), the water has a bad taste and odour.

State the name of a substance that is added to remove the bad taste and odour from the water.

..... [1]

[Total: 10]



- 4 (a) Compound **B** is a molecule found in a plant called basil.

Fig. 4.1 shows the displayed formula of a molecule of compound **B**.

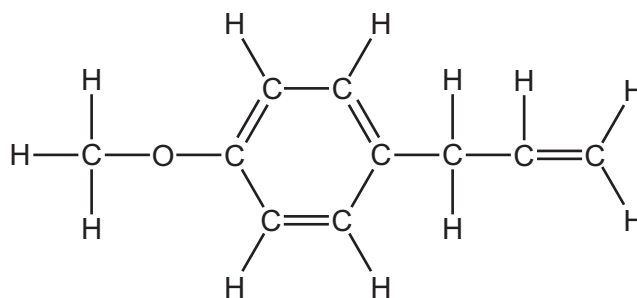


Fig. 4.1

Deduce the molecular formula of compound **B** to show the number of atoms of carbon, hydrogen and oxygen.

..... [1]

- (b) On Fig. 4.1, draw a circle around **one** part of the molecule which shows that the molecule is unsaturated. [1]

- (c) A different molecule found in plants has the molecular formula $C_9H_{10}O_3$.

Complete Table 4.1 to calculate the relative molecular mass of $C_9H_{10}O_3$.

Table 4.1

type of atom	number of atoms	relative atomic mass	
carbon	9	12	$9 \times 12 = 108$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]



- (d) Fig. 4.2 shows the names of some of the fractions obtained from petroleum using a fractionating column.

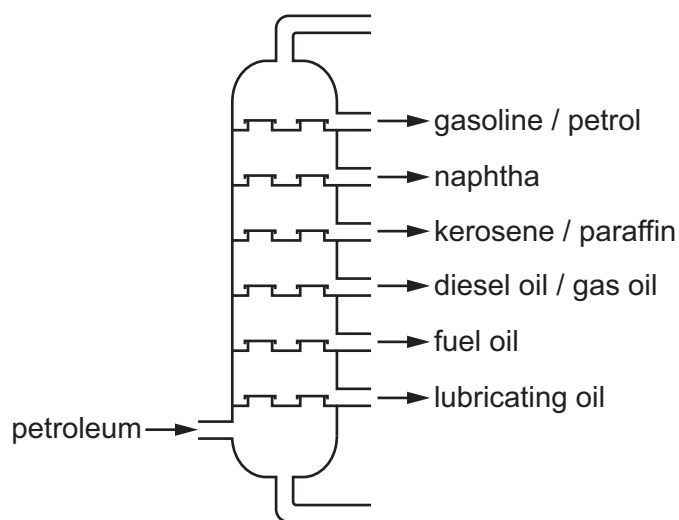


Fig. 4.2

Using only the fractions shown in Fig. 4.2, name the fraction which contains compounds that:

- (i) have the highest boiling point

..... [1]

- (ii) have the shortest chain length

..... [1]

- (iii) are used to make waxes and polishes.

..... [1]



(e) Table 4.2 shows some properties of alcohols.

Table 4.2

name	formula	melting point /°C	boiling point /°C
hexanol	C ₆ H ₁₃ OH	−45	157
heptanol	C ₇ H ₁₅ OH	−35	176
octanol		−16	195
nonanol	C ₉ H ₁₉ OH		214
decanol	C ₁₀ H ₂₁ OH	7	233

(i) The compounds in Table 4.2 are members of the alcohol homologous series.

State what is meant by the term homologous series.

.....
 [1]

(ii) A molecule of octanol has eight carbon atoms.

Use the information in Table 4.2 to deduce the formula of octanol.

..... [1]

(iii) Use the information in Table 4.2 to predict the melting point of nonanol.

..... [1]

(f) (i) Hexanol is a fuel. In excess oxygen, hexanol undergoes complete combustion to produce water and one other product.

Identify this other product.

..... [1]

(ii) State the colour change observed when water is added to anhydrous copper(II) sulfate.

from white to

[1]



(g) Ethanol can be manufactured by fermentation.

Name the reactant, and state **two** conditions needed for the fermentation of ethanol.

reactant

condition 1

condition 2

[3]

(h) Ethanol can be converted into ethanoic acid.

Draw the displayed formula of ethanoic acid. Show all the atoms and all the bonds.

[2]

[Total: 17]



- 5 This question is about elements in different groups of the Periodic Table and their compounds.

- (a) Silicon is in Group IV of the Periodic Table.

Explain why silicon is placed in Group IV.
Give your answer in terms of electronic configuration.

..... [1]

- (b) Tin is also in Group IV of the Periodic Table.

Table 5.1 shows the melting point and the boiling point of tin.

Table 5.1

melting point/°C	232
boiling point/°C	2602

Use Table 5.1 to deduce the physical state of tin at 175 °C.

Give a reason for your answer.

physical state

reason

..... [2]

- (c) Iodine is in Group VII of the Periodic Table.

Give the colour and state of iodine at room temperature and pressure.

colour

state

[2]



(d) When a sample of calcium is added to a large container of cold water, a chemical reaction occurs.

(i) Describe what is observed when calcium is added to water.

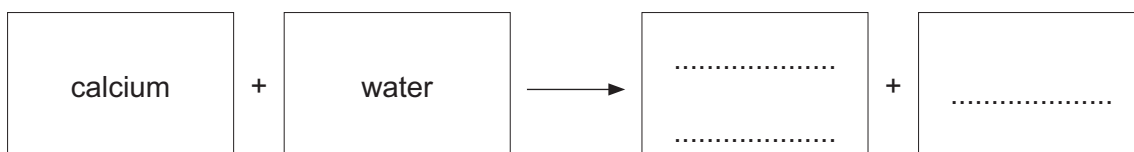
.....

.....

.....

..... [2]

(ii) Complete the word equation for the reaction of calcium with water.



[2]

(e) Dilute nitric acid is poured into a conical flask.

(i) Choose the pH value of dilute nitric acid.

Draw a circle around your chosen answer.

pH 1

pH 7

pH 9

pH 13

[1]

(ii) Complete the equation for the neutralisation of an acid to produce water.

State symbols are not required.



[1]

(iii) A few drops of methyl orange indicator are added to the flask containing dilute nitric acid.

Solid lithium carbonate is slowly added to the flask until the indicator changes colour.

State the colour change of the methyl orange indicator as the lithium carbonate is added to the dilute nitric acid in the flask.

from to [2]



(f) Lithium carbonate reacts with dilute nitric acid to form aqueous lithium nitrate.

Describe a test to show that Li^+ ions are present in the solution.

test

observations

[2]

(g) Chlorine is in Group VII of the Periodic Table.

Chlorine reacts with lithium to form the ionic compound lithium chloride.

Complete the dot-and-cross diagram in Fig. 5.1 for lithium chloride to show:

- the electronic configuration for each ion
- the charge on each ion.

Use crosses to represent the electrons of lithium.

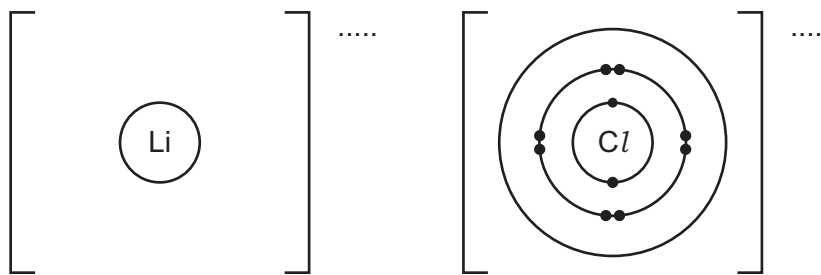


Fig. 5.1

[3]

[Total: 18]





Question 6 starts on the next page.



6 This question is about metals.

(a) Iron is extracted from its ore using carbon in a blast furnace.

When calcium carbonate is heated strongly in the blast furnace, it forms calcium oxide and carbon dioxide.



(i) State the type of reaction that occurs when calcium carbonate is heated strongly.

..... [1]

(ii) State whether calcium oxide is an acidic oxide or a basic oxide.

Explain your answer.

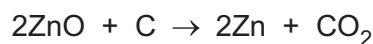
.....
..... [1]

(iii) Name the gas removed by calcium oxide in flue gas desulfurisation.

..... [1]

(b) Zinc is also extracted from its ore using carbon.

(i) The equation for the extraction of zinc from zinc oxide is shown.



Explain how this equation shows that zinc oxide is reduced.

.....
..... [1]

(ii) Brass is an alloy that contains zinc.

Name the **other** metal in brass.

..... [1]

(iii) Suggest **two** reasons why brass is used to make water taps rather than pure zinc.

1
2
[2]



(c) The extraction of zinc from its ore produces atmospheric sulfur dioxide and carbon dioxide.

(i) State the adverse effect that increased levels of sulfur dioxide have on the environment.

..... [1]

(ii) Increased levels of carbon dioxide in the atmosphere can lead to increased global warming.

State **one** strategy which would help to remove carbon dioxide that is already in the atmosphere.

..... [1]

(d) Table 6.1 shows the observations when four different metals are added separately to dilute hydrochloric acid.

Table 6.1

metal	observations
Fe	a few bubbles of gas given off very slowly and the temperature of the mixture increases very slowly
W	no bubbles of gas given off and no temperature increase of the mixture
Ba	many bubbles of gas given off very quickly and the temperature of the mixture increases rapidly
Mg	bubbles of gas given off quickly and the temperature of the mixture increases slowly

Put the four metals in order of their reactivity.

Put the least reactive metal first.

least reactive $\longrightarrow$ most reactive

--	--	--	--

[2]

[Total: 11]



- 7 Fig. 7.1 shows the apparatus used to electroplate a nickel object with copper.

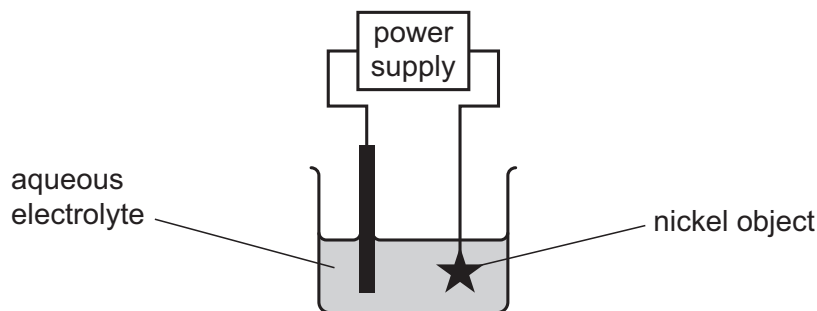


Fig. 7.1

- (a) Label the anode in Fig. 7.1. [1]

- (b) Name a suitable aqueous electrolyte for the electroplating in Fig. 7.1.

..... [1]

- (c) Fig. 7.2 shows the apparatus used to electrolyse molten lead(II) bromide using inert electrodes.

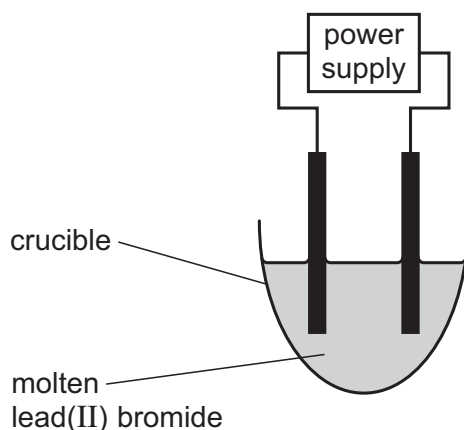


Fig. 7.2

State the colour of the gas produced at the anode in this electrolysis.

..... [1]

- (d) State whether the electrolysis of molten lead(II) bromide produces a physical or chemical change.

Explain your answer.

type of change

explanation

..... [1]



(e) Cobalt is a metal that reacts slowly with a dilute acid to produce cobalt(II) ethanoate and hydrogen.

(i) Name the dilute acid.

..... [1]

(ii) Describe a test for hydrogen.

test

observations [1]

(f) Cobalt(II) chloride, CoCl_2 , exists in different forms.

Draw **one** line from each form of cobalt(II) chloride to its description.

form of cobalt(II) chloride

description

hydrated CoCl_2

solid CoCl_2
containing no water

aqueous CoCl_2

solid CoCl_2 chemically
combined with water

anhydrous CoCl_2

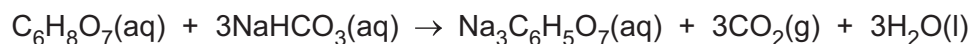
CoCl_2 dissolved in water

[2]

[Total: 8]



- 8 Excess dilute citric acid, $\text{C}_6\text{H}_8\text{O}_7$, is added to aqueous sodium hydrogencarbonate to form aqueous sodium citrate, $\text{Na}_3\text{C}_6\text{H}_5\text{O}_7$, carbon dioxide and water.



- (a) Give the meaning of the symbol (l) in the equation.

..... [1]

- (b) Fig. 8.1 shows the total volume of carbon dioxide gas, CO_2 , produced as the reaction proceeds.

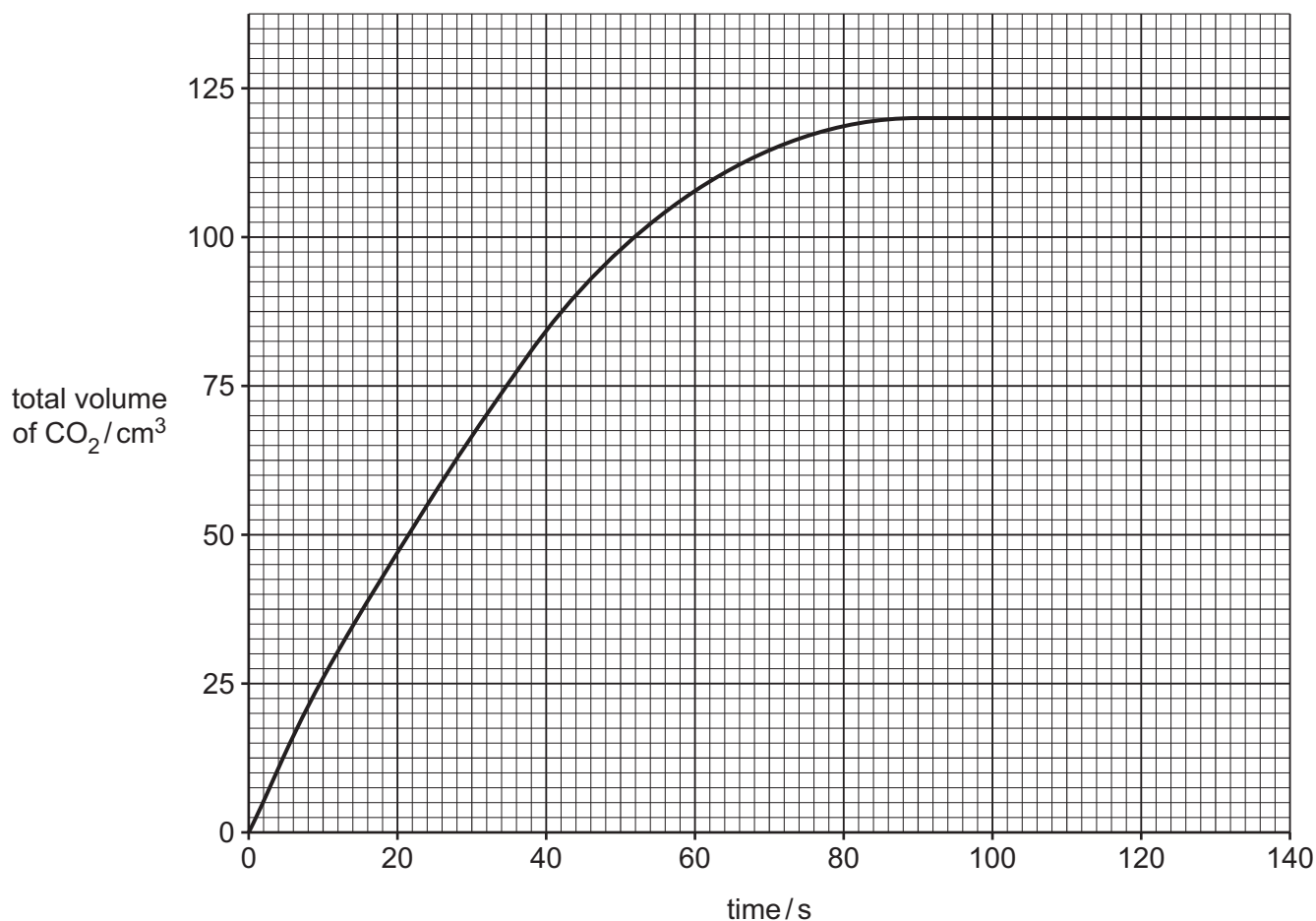


Fig. 8.1

Use Fig. 8.1 to determine the total volume of CO_2 produced at 24 s.

total volume of CO_2 at 24 s = ... cm^3 [1]



- (c) The reaction is repeated using excess citric acid of a lower concentration.

All other conditions stay the same.

State the effect, if any, on:

- (i) the time taken for the reaction to finish

..... [1]

- (ii) the total volume of CO_2 produced when the reaction is complete.

..... [1]

- (d) Fig. 8.2 shows the reaction pathway diagram for the reaction of dilute citric acid with aqueous sodium hydrogencarbonate.

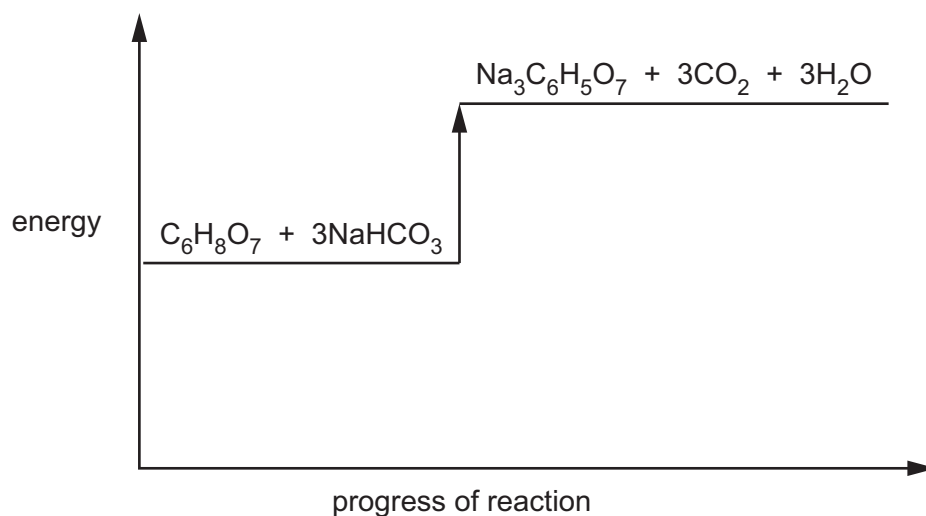


Fig. 8.2

Deduce the type of energy change shown in the diagram in Fig. 8.2.

Explain your answer.

.....

 [2]

[Total: 6]

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The Periodic Table of Elements

Group																			
I	II	Key										III	IV	V	VI	VII	VIII		
		atomic number atomic symbol name relative atomic mass										1 H hydrogen 1							
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	2 He helium 4		
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40		
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84		
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium —	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131		
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids		72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —	85 At astatine —	86 Rn radon —	
87 Fr francium —	88 Ra radium —	89–103 actinoids		104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	113 Nh nihonium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	117 Ts tennessine —	118 Og oganesson —	

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium —	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium —	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).