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CHEMISTRY **0620/41**

Paper 4 Theory (Extended) **May/June 2026**

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. Do **not** use correction fluid or tape.
- 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. Any blank pages are indicated.

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[Turn over

1 A list of symbol equations and word equations, **A** to **J**, is shown.

A ethene + hydrogen → ethane

B $2KBr + Cl_2 \rightarrow 2KCl + Br_2$

C $Al^{3+} + 3e^- \rightarrow Al$

D glucose → ethanol + carbon dioxide

E $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

F $N_2 + 3H_2 \rightarrow 2NH_3$

G calcium carbonate → calcium oxide + carbon dioxide

H $C_8H_{18} \rightarrow C_6H_{14} + C_2H_4$

I sulfur dioxide + oxygen → sulfur trioxide

J glucose + oxygen → carbon dioxide + water

Each equation may be used once, more than once, or not at all.

Give the letter, **A** to **J**, for the equation that represents:

(a) a reaction that occurs in the blast furnace

..... [1]

(b) a reaction catalysed by vanadium(V) oxide

..... [1]

(c) cracking

..... [1]

(d) photosynthesis

..... [1]

(e) a reaction that occurs in the Haber process

..... [1]

(f) a displacement reaction

..... [1]

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(g) a reaction catalysed by yeast.

..... [1]

[Total: 7]

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2 This question is about elements.

(a) Identify the element that:

(i) is used in the manufacture of overhead electrical cables because of its low density

..... [1]

(ii) is in Group VII and Period 4 of the Periodic Table

..... [1]

(iii) contains atoms with exactly 23 protons

..... [1]

(iv) kills microbes in the domestic water supply

..... [1]

(v) is approximately 78% of clean, dry air

..... [1]

(vi) has an acidic oxide which forms slag in the blast furnace.

..... [1]

(b) Isotopes are different atoms of the same element.

(i) Explain, in terms of protons and neutrons, the similarity and difference between isotopes of the same element.

.....

..... [2]

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(ii) A sample of magnesium contains three isotopes.

Table 2.1 shows the percentage abundances and the relative masses of the three isotopes of magnesium in this sample.

Table 2.1

percentage abundance	relative mass
80	24
10	25
10	26

Calculate the relative atomic mass of magnesium to **one** decimal place.

relative atomic mass = ... [2]

[Total: 10]

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3 This question is about structure and bonding.

(a) Magnesium fluoride is an ionic compound.

(i) In Figure 3.1, complete the dot-and-cross diagrams to show the bonding in magnesium fluoride. The inner shells of electrons are shown.

Show the charge on each ion.

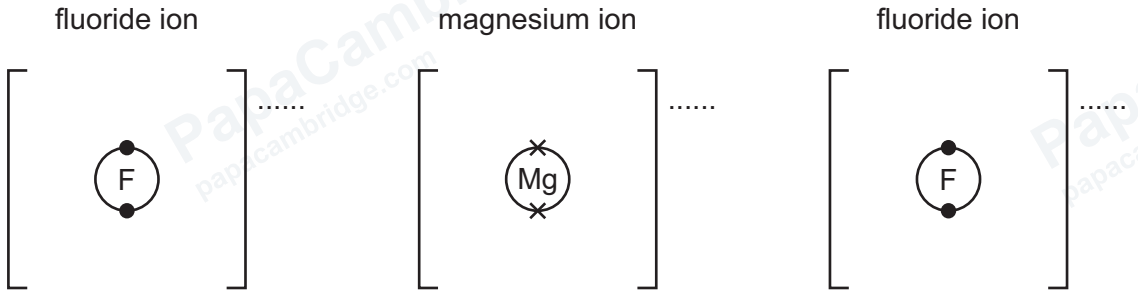

Figure 3.1

[3]

(ii) Explain why magnesium fluoride has a high melting point.

.....

.....

.....

..... [2]

(iii) Explain why magnesium fluoride conducts electricity when it is molten.

.....

..... [1]

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(b) Fluorine, F_2, consists of simple molecules.

(i) In Figure 3.2, complete the dot-and-cross diagram of a molecule of fluorine.

Show outer shell electrons only.

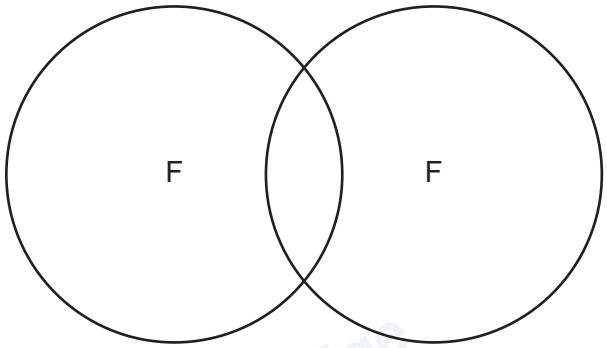

Figure 3.2

[2]

(ii) The melting point and boiling point of fluorine are shown in Table 3.1.

Table 3.1

melting point / °C	–220
boiling point / °C	–188

Deduce the physical state of fluorine at –240 °C.

Use the data in Table 3.1 to explain your answer.

physical state .....

explanation .....

.....

[2]

[Total: 10]

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4 Aqueous hydrogen peroxide, H_2O_2, decomposes to produce water and oxygen gas.

Manganese(IV) oxide is a catalyst in this reaction.

A student adds powdered manganese(IV) oxide to aqueous hydrogen peroxide in a conical flask as shown in Figure 4.1. The volume in the gas syringe is measured at regular time intervals. The volume increases as time increases.

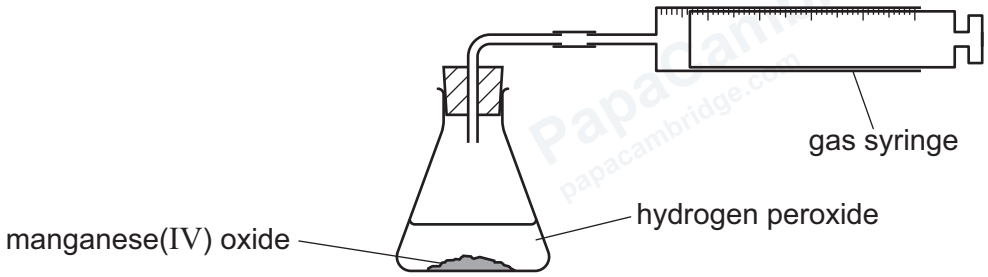

Figure 4.1

(a) Write a symbol equation for the decomposition of aqueous hydrogen peroxide.

Include state symbols.

..... [3]

(b) State what is meant by the term catalyst.

.....

..... [2]

(c) The rate of reaction is highest at the start of the reaction. The rate of reaction decreases as time increases. The reaction eventually stops.

(i) Explain why the rate of reaction is highest at the start of the reaction.

.....

..... [1]

(ii) Explain why the reaction stops.

.....

..... [1]

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(d) The experiment is repeated at a lower temperature.

Explain why the rate of reaction is lower at the lower temperature.

.....

.....

.....

.....

..... [3]

[Total: 10]

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5 This question is about the effects of electricity on chemical substances.

(a) Dilute aqueous sodium chloride decomposes when an electric current is passed through it. Graphite electrodes are used.

The products are:

- oxygen at the anode
- hydrogen at the cathode.

(i) Name the process that occurs when an aqueous ionic compound decomposes by the passage of an electric current.

..... [1]

(ii) Give **two** reasons why graphite is suitable for use as an electrode.

1 .....

2 .....

[2]

(iii) Write an ionic half-equation for the formation of hydrogen at the cathode.

..... [2]

(iv) Explain why oxygen is produced at the anode.

.....

..... [2]

(v) Name the type of particle responsible for the transfer of charge in the conducting wires of the external circuit.

..... [1]

(vi) Name the products formed at each electrode when an electric current is passed through **concentrated** aqueous sodium chloride.

anode .....

cathode .....

[2]

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(b) Aluminium is extracted when electricity is used to decompose an electrolyte containing a purified ore of aluminium. The electrodes are made of carbon.

(i) Name the ore of aluminium that is purified.

..... [1]

(ii) Name the compound of aluminium that is present in this ore of aluminium.

..... [1]

(iii) Name the substance that the compound of aluminium in **5(b)(ii)** is dissolved in during this extraction.

..... [1]

(iv) Explain why the carbon anodes have to be replaced.

.....

..... [2]

[Total: 15]

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6 This question is about metallic compounds.

(a) Zinc oxide, ZnO, reacts with both acids and alkalis to produce salts.

(i) State the term given to oxides that react with both acids and alkalis.

..... [1]

(ii) When zinc oxide reacts with aqueous sodium hydroxide it forms sodium zincate.

Sodium zincate contains sodium ions, Na^+, and zincate ions, ZnO_2^{2-}.

Write the formula of sodium zincate.

..... [1]

(iii) The reaction between zinc oxide and dilute sulfuric acid forms aqueous zinc sulfate as one of the products.

Write the symbol equation for the reaction between zinc oxide and dilute sulfuric acid.

..... [2]

(iv) When aqueous barium chloride is added to aqueous zinc sulfate, a precipitate of barium sulfate, $BaSO_4$, is produced.

Write an ionic equation for this precipitation reaction.

Include state symbols.

..... [2]

(v) Give the colour of the precipitate that forms in **6(a)(iv)**.

..... [1]

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(b) (i) Chromium(III) oxide is a product of the thermal decomposition of potassium dichromate(VI), $K_2Cr_2O_7$. The other products are potassium chromate(VI), K_2CrO_4, and oxygen, O_2.

The equation for the thermal decomposition is shown.

$$4K_2Cr_2O_7 \rightarrow 4K_2CrO_4 + 2Cr_2O_3 + 3O_2$$

Calculate the maximum mass of Cr_2O_3 that is produced by the thermal decomposition of 11.76 g of $K_2Cr_2O_7$.

[M_r: $K_2Cr_2O_7$, 294; Cr_2O_3, 152]

Use the following steps.

- Calculate the number of moles of $K_2Cr_2O_7$ used.

..... mol

- Calculate the number of moles of Cr_2O_3 formed.

..... mol

- Calculate the mass of Cr_2O_3 formed.

..... g
[3]

(ii) Give the meaning of (VI) in potassium chromate(VI).

.....

..... [2]

(iii) Potassium dichromate(VI) is an orange solid.

Identify the element which causes potassium dichromate(VI) to be coloured.

..... [1]

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(c) Dinitrogen tetroxide, N_2O_4, decomposes into nitrogen dioxide, NO_2. The reaction is reversible.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

The forward reaction is endothermic.

A mixture of N_2O_4 and NO_2 gases are allowed to reach equilibrium in a closed container.

Complete Table 6.1 using **only** the words **increases**, **decreases** or **no change**.

Table 6.1

change in condition	effect on the equilibrium concentration of $NO_2(g)$
pressure increases	
temperature decreases	
addition of a suitable catalyst	

[3]

[Total: 16]

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7 This question is about hydrocarbons.

(a) Alkanes are a homologous series of hydrocarbons.

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

..... [1]

(ii) State **two** characteristics that all individual members of the same homologous series have in common.

1 .....

2 .....

[2]

(iii) Give the molecular formula of the alkane that has 10 carbon atoms.

..... [1]

(b) Propane reacts with chlorine in a photochemical reaction. An equation for the reaction is shown.

$$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$$

(i) State the meaning of the term photochemical.

.....

..... [1]

(ii) Draw the displayed formula of **two** structural isomers with the formula C_3H_7Cl.

[2]

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(c) Addition polymers are made from alkenes.

(i) Give the empirical formula of all alkenes.

..... [1]

(ii) Name **two** unbranched alkene molecules that each contain four carbon atoms.

1 .....

2 .....

[2]

(iii) Complete Figure 7.1 to show one repeat unit of the addition polymer formed from propene.

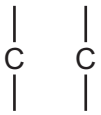

Figure 7.1

[2]

[Total: 12]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
							1 H hydrogen 1										2 He helium 4
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	10 Ne neon 20
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 –

Key

atomic number
atomic symbol
name
relative atomic mass

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 dm^3 at room temperature and pressure (r.t.p.).

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