



# Cambridge IGCSE™

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**CHEMISTRY****0620/42**

Paper 4 Theory (Extended)

**February/March 2023****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 **12** pages.

1 This question is about gases found in clean, dry air and gases found in polluted air.

(a) Name **one** gas found in clean, dry air which contributes to global warming.

..... [1]

(b) State the percentage of nitrogen in clean, dry air.

..... [1]

(c) Name the substance used to remove sulfur dioxide in flue gas desulfurisation.

..... [1]

(d) Nitrogen dioxide,  $\text{NO}_2$ , is formed in car engines.

Name the equipment in a car exhaust used to remove the  $\text{NO}_2$  formed in car engines.

..... [1]

(e) All gases diffuse.

(i) Choose from the list of formulae the gas which diffuses most quickly.

Draw a circle around your answer.

CO       $\text{CO}_2$        $\text{CH}_4$        $\text{NO}_2$        $\text{SO}_2$

[1]

(ii) Explain your answer to (i).

..... [1]

(f) State **one** adverse effect of carbon monoxide on human health.

..... [1]

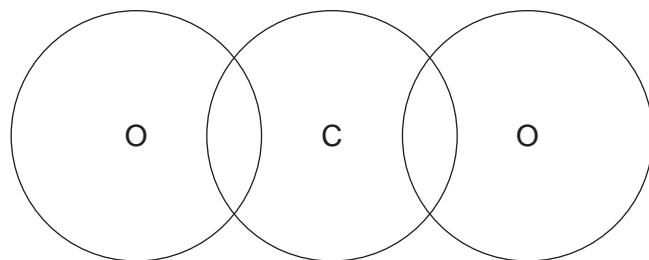
(g) Carbon dioxide,  $\text{CO}_2$ , is a reactant in photosynthesis.

Name the **two** products of photosynthesis.

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

(h) Complete the dot-and-cross diagram in Fig. 1.1 for a molecule of  $\text{CO}_2$ .

Show outer shell electrons only.



**Fig. 1.1**

[2]

[Total: 11]

- 2** Lithium, sodium and potassium are Group I elements.

- (a) Name the type of bonding in these elements.

..... [1]

- (b) Sodium reacts with cold water to form hydrogen gas and a solution of a strong alkali.

- (i) State the test for hydrogen gas.

test .....

positive result .....

[1]

- (ii) Suggest the pH of a solution of a strong alkali.

pH = ..... [1]

- (iii) Name a substance which can be used to confirm the pH of a solution of a strong alkali.

..... [1]

- (iv) Write the symbol equation for the reaction between sodium and cold water.

Include state symbols.

..... [3]

- (c) Lithium has two naturally occurring types of atoms,  ${}^6\text{Li}$  and  ${}^7\text{Li}$ .

- (i) State the name given to atoms of the same element with different nucleon numbers.

..... [1]

- (ii) Complete Table 2.1 to show the number of protons, neutrons and electrons in the atom and ion of lithium shown.

**Table 2.1**

	${}^6\text{Li}$	${}^7\text{Li}^+$
protons		
neutrons		
electrons		

[3]

- (iii) Table 2.2 shows the relative abundance of the two naturally occurring atoms of lithium.

**Table 2.2**

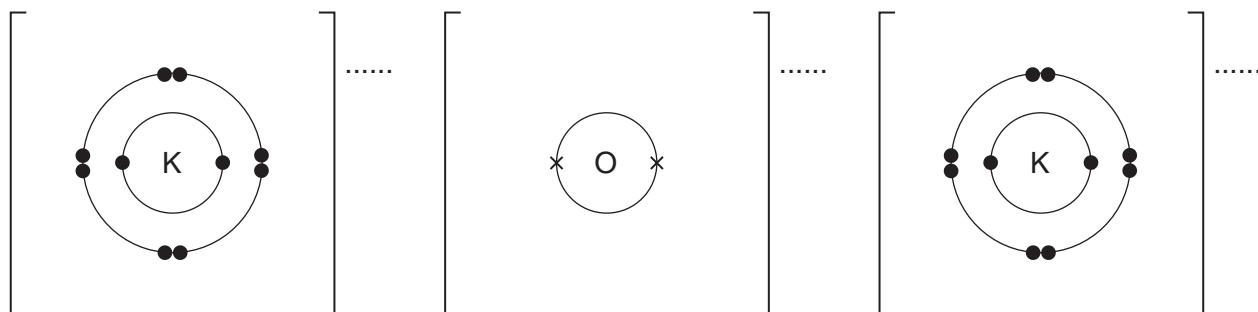
atom	${}^6\text{Li}$	${}^7\text{Li}$
relative abundance	10%	90%

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

$$\text{relative atomic mass} = \dots\dots\dots [2]$$

- (d) Potassium oxide,  $\text{K}_2\text{O}$ , is an ionic compound.

Complete Fig. 2.1 to show the electronic configurations of the ions in potassium oxide. Show the charges on the ions.



**Fig. 2.1**

[3]

[Total: 16]

- 3 The Haber process is used to manufacture ammonia.

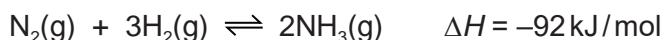
- (a) State the main source of each gas used in the Haber process.

nitrogen .....

hydrogen .....

[2]

- (b) The equation for the Haber process is shown.



The reaction is reversible. The forward reaction is exothermic.

- (i) State what is meant by the symbol  $\Delta H$ .

..... [1]

- (ii)  $\Delta H$  for the forward reaction is  $-92 \text{ kJ/mol}$ .

State why this value shows that the forward reaction is exothermic.

..... [1]

- (iii) State the typical conditions and name the catalyst used in the Haber process.

temperature .....  $^{\circ}\text{C}$

pressure ..... kPa

catalyst .....

[3]

- (iv) Complete Table 3.1 to show the effect, if any, when the typical conditions in the Haber process are changed. Use only the words **increases**, **decreases** or **no change**.

**Table 3.1**

change to typical conditions	effect on the rate of the forward reaction	effect on the concentration of $\text{NH}_3(\text{g})$ at equilibrium
temperature increases	increases	
pressure decreases		
no catalyst	decreases	

[4]

- (v) Explain in terms of collision theory why increasing the temperature increases the rate of the reaction.

.....  
.....  
.....  
.....  
..... [3]

- (c) Ammonia reacts with an acid to form ammonium sulfate,  $(\text{NH}_4)_2\text{SO}_4$ .

- (i) State the formula of the acid used.

..... [1]

- (ii) State **one** use of ammonium sulfate.

..... [1]

- (iii) Calculate the percentage composition by mass of nitrogen in  $(\text{NH}_4)_2\text{SO}_4$ .

percentage of nitrogen = ..... % [2]

[Total: 18]

4 Copper is element 29 in the Periodic Table.

(a) Brass contains copper.

(i) Name the other metal in brass.

..... [1]

(ii) State the term given to a mixture of a metal with another element.

..... [1]

(b) Copper can be stretched into wires. Copper wires conduct electricity.

(i) Name the property of metals which means that they can be stretched into wires.

..... [1]

(ii) Name the particles responsible for the conduction of electricity in solid copper.

..... [1]

(c) Copper is a transition element.

Some physical and chemical properties of transition elements are shown.

physical properties:

- high density
- high strength

chemical properties:

- form coloured compounds
- have ions with variable oxidation numbers

(i) State one **other** physical property of transition elements.

..... [1]

(ii) State one **other** chemical property of transition elements.

..... [1]

**(d)** Hydrated copper(II) sulfate is a coloured compound. It exists as hydrated crystals which contain water molecules.

- (i)** State the term given to water molecules present in hydrated crystals.

..... [1]

- (ii)** State the colour of hydrated copper(II) sulfate crystals.

..... [1]

- (iii)** Write the formula of hydrated copper(II) sulfate.

..... [2]

**(e)** Copper(II) oxide is formed when copper(II) nitrate,  $\text{Cu}(\text{NO}_3)_2$ , is heated.



- (i)** State the class of oxide to which copper(II) oxide belongs.

..... [1]

- (ii)** State the meaning of the Roman numeral (II) in the name copper(II) oxide.

..... [1]

- (iii)** 0.0200 moles of  $\text{Cu}(\text{NO}_3)_2$  is heated.

Calculate the mass of 0.0200 moles of  $\text{Cu}(\text{NO}_3)_2$ .

mass = ..... g [2]

- (iv)** Calculate the **total** volume of gas, in  $\text{dm}^3$  at r.t.p., produced when 0.0200 moles of  $\text{Cu}(\text{NO}_3)_2$  is heated.

volume = .....  $\text{dm}^3$  [2]

- (v)** Powdered aluminium reduces copper(II) oxide.

Write the symbol equation for this reaction.

..... [2]

[Total: 18]

- 5 Propane, propene, propan-1-ol and propanoic acid are members of different homologous series. Molecules of these substances contain three carbon atoms.

(a) Explain why members of a homologous series have similar chemical properties.

..... [1]

(b) Name the homologous series to which propanoic acid belongs.

..... [1]

(c) State the general formula of the homologous series to which propanoic acid belongs.

..... [1]

(d) Propan-1-ol has an unbranched isomer.

- Name this isomer.

.....

- Draw the displayed formula of this isomer.

[2]

(e) Propane and propene can be manufactured by heating decane, C<sub>10</sub>H<sub>22</sub>, in the presence of a catalyst. One other product is formed.

(i) Complete the equation for this reaction.



(ii) Name this manufacturing process.

..... [1]

(f) Propene forms a polymer named poly(propene).

(i) Draw the displayed formula of a section of poly(propene) showing **three** repeat units.

[2]

(ii) State the type of polymerisation that occurs when propene forms poly(propene).

..... [1]

(g) Propanoic acid reacts with aqueous sodium carbonate to form a salt.

(i) Suggest the name of the salt formed.

..... [1]

(ii) Suggest the formula of the anion in this salt.

..... [1]

(h) Propanoic acid forms an ester when it reacts with ethanol in the presence of a catalyst.

(i) Suggest a suitable catalyst.

..... [1]

(ii) Name the ester formed.

..... [1]

(iii) Draw the displayed formula of this ester.

[2]

[Total: 17]

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## The Periodic Table of Elements

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

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

The volume of one mole of any gas is  $24\text{dm}^3$  at room temperature and pressure (r.t.p.).