Cambridge Assessment International Education

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CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

5375001254

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.

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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, NO_2, is formed in car engines.

Name the equipment in a car exhaust used to remove the 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 **CO_2** **CH_4** **NO_2** **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, CO_2, is a reactant in photosynthesis.

Name the **two** products of photosynthesis.

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

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(h) Complete the dot-and-cross diagram in Fig. 1.1 for a molecule of CO_2.

Show outer shell electrons only.

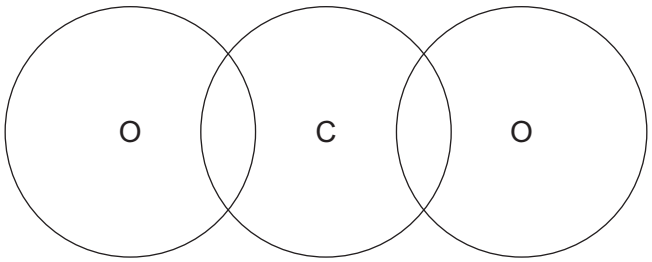


Fig. 1.1

[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}Li and ^{7}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}Li	$^{7}Li^{+}$
protons		
neutrons		
electrons		

[3]

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

Table 2.2

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

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

relative atomic mass = ... [2]

(d) Potassium oxide, K_2O, 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.

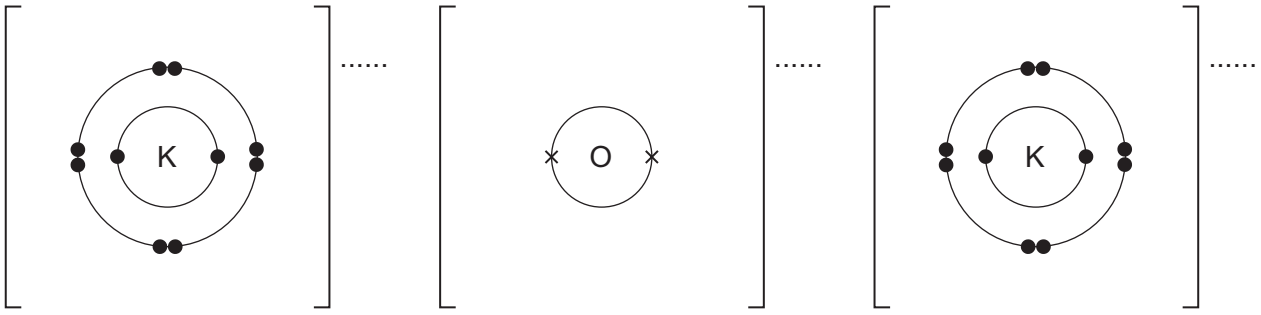


Fig. 2.1

[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.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ/mol$$

The reaction is reversible. The forward reaction is exothermic.

(i) State what is meant by the symbol ΔH.

..... [1]

(ii) ΔH for the forward reaction is –92 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 ..... °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 $NH_3(g)$ 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, $(NH_4)_2SO_4$.

(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 $(NH_4)_2SO_4$.

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]

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(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, $Cu(NO_3)_2$, is heated.

$$2Cu(NO_3)_2(s) \rightarrow 2CuO(s) + 4NO_2(g) + O_2(g)$$

(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 $Cu(NO_3)_2$ is heated.

Calculate the mass of 0.0200 moles of $Cu(NO_3)_2$.

mass = ... g [2]

(iv) Calculate the **total** volume of gas, in dm^3 at r.t.p., produced when 0.0200 moles of $Cu(NO_3)_2$ is heated.

volume = ... dm^3 [2]

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

Write the symbol equation for this reaction.

..... [2]

[Total: 18]

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[Turn over

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, $C_{10}H_{22}$, in the presence of a catalyst. One other product is formed.

(i) Complete the equation for this reaction.

$C_{10}H_{22} \rightarrow$ ..... + ... + ... [2]

(ii) Name this manufacturing process.

..... [1]

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(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

Group																	
I	II											III	IV	V	VI	VII	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.).