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CHEMISTRY **0620/33**

Paper 3 Theory (Core) **October/November 2024**

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.

[Turn over

1 Fig. 1.1 shows part of the Periodic Table.

I	II										III	IV	V	VI	VII	VIII
							H									He
Li													N			Ne
											Al					
K	Ca				Cr		Fe					Zn					
Rb										Ag						I	
										Au							

Fig. 1.1

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

Give the symbol of the element that:

(i) is in brass

..... [1]

(ii) produces an orange-red colour in a flame test

..... [1]

(iii) is a reactant in a fuel cell

..... [1]

(iv) has an atom with only three occupied electron shells

..... [1]

(v) forms an ion that gives a red-brown precipitate on addition of aqueous ammonia

..... [1]

(vi) forms an ion with a charge of 1–.

..... [1]

(b) Explain why Li, K and Rb have similar chemical properties.

.....

.....

..... [2]

[Total: 8]

2 Oxygen, water and ethene have simple molecular structures.

(a) (i) State the percentage of oxygen in clean, dry air.

..... [1]

(ii) Complete Fig. 2.1 to show the dot-and-cross diagram for a molecule of water.
Show outer shell electrons only.

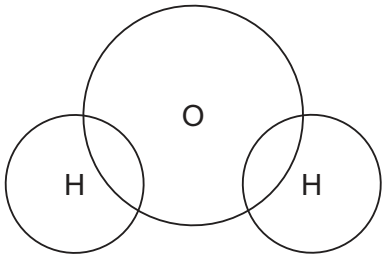

Fig. 2.1

[2]

(iii) Ethene is a small molecule used to make polymers.

State the name of the polymer formed from ethene.

..... [1]

(iv) Complete this sentence about polymers.

Polymers are large molecules built up from many smaller molecules called

..... . [1]

(b) Potassium chloride is an ionic compound.

(i) State **two** physical properties of ionic compounds.

1 .....

2 .....

[2]

(ii) Choose the correct statement that describes ionic bonding.

Tick (✓) **one** box.

It is a weak electrostatic attraction between anions and cations. ☐

It is a weak electrostatic attraction between cations. ☐

It is a strong electrostatic attraction between anions. ☐

It is a strong electrostatic attraction between cations and anions. ☐

[1]

[Total: 8]

3 **(a)** The list shows some gases in a sample of water.

Choose from the list the gas that is essential for aquatic life.

Draw a circle around your chosen answer.

argon **hydrogen** **nitrogen** **oxygen** [1]

(b) Polluted water contains harmful substances.

Link each harmful substance on the left to the correct effect on the right.
One has been done for you.

harmful substance	**effect**
plastics	are toxic to aquatic organisms
metal compounds such as mercury(II) chloride	contains harmful microbes which cause disease
sewage	harm aquatic life when eaten
nitrates	lead to deoxygenation of water

[1]

Question 3 continues on the next page.

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

Table 3.1

name of ion	formula of ion	mass of ion in 1000 cm^3 of polluted water / mg
bromide	Br^-	0.1
calcium	Ca^{2+}	2.0
chloride	Cl^-	3.5
hydrogencarbonate	HCO_3^-	12.0
magnesium	Mg^{2+}	0.8
mercury	Hg^{2+}	0.3
nitrate	NO_3^-	0.4
phosphate	PO_4^{3-}	2.0
potassium	K^+	6.4
silicate	SiO_3^{2-}	4.0
sodium	Na^+	10.2
	SO_4^{2-}	0.5
tin	Sn^{2+}	0.2

Answer these questions using the information from Table 3.1.

(i) Name the positive ion that has the lowest concentration.

..... [1]

(ii) State the name of the SO_4^{2-} ion.

..... [1]

(iii) Calculate the mass of potassium ions in 125 cm^3 of polluted water.

mass = ... mg [1]

(d) Name **two** substances used in the treatment of the domestic water supply.
For each substance give a reason for its use.

substance 1 .....

reason .....

substance 2 .....

reason .....

[4]

(e) Complete the symbol equation for the reaction of silicon(IV) chloride, $SiCl_4$, with water.

$$SiCl_4 + ...H_2O \rightarrow SiO_2 + ...HCl$$ [2]

[Total: 11]

4 **(a)** Fig. 4.1 shows the displayed formula of compound **A**.

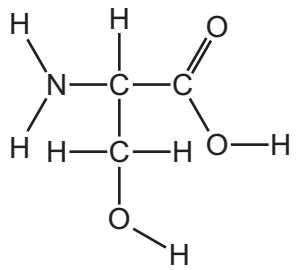

Fig. 4.1

(i) On Fig 4.1 draw a circle around the carboxylic acid functional group. [1]

(ii) Deduce the molecular formula of compound **A**.

..... [1]

(b) Compound **A** reacts with ethanol to produce a compound with the molecular formula $C_5H_{11}NO_3$.

Complete Table 4.1 to calculate the relative molecular mass of $C_5H_{11}NO_3$.

Table 4.1

type of atom	number of atoms	relative atomic mass	
carbon	5	12	$5 \times 12 = 60$
hydrogen		1	
nitrogen		14	
oxygen		16	

relative molecular mass = ... [2]

Question 4 continues on the next page.

(c) Table 4.2 shows the names, formulae and boiling points of methanol, ethanol, propanol and butanol.

Table 4.2

name	formula	boiling point / °C
methanol	CH_3OH	65
ethanol	C_2H_5OH	79
propanol	C_3H_7OH	98
butanol	C_4H_9OH	117

Use the information in Table 4.2 to answer these questions.

(i) Name the homologous series that includes methanol, ethanol, propanol and butanol.

..... [1]

(ii) Deduce the general formula of this homologous series.

..... [1]

(iii) State the trend in the boiling point of this homologous series as the number of carbon atoms increases.

..... [1]

(d) Ethanol can be manufactured by an addition reaction.

(i) Name **two** substances and state **two** conditions required.

substance 1 .....

substance 2 .....

condition 1 .....

condition 2 .....

[4]

(ii) Draw the displayed formula of ethanol.

[1]

(iii) Name the toxic gas produced when ethanol undergoes incomplete combustion.

..... [1]

[Total: 13]

5 **(a)** Table 5.1 shows some properties of five halogens.

Table 5.1

halogen	melting point in °C	boiling point in °C	atomic volume in cm^3 / mol
fluorine	–220	–188	
chlorine	–101	–35	22.7
bromine	–7	+59	25.6
iodine	+114	+184	25.8
astatine		+337	32.8

Use the information in Table 5.1 to predict:

(i) the melting point of astatine ..... [1]

(ii) the atomic volume of fluorine ..... [1]

(iii) the physical state of fluorine at –240 °C. Give a reason for your answer.

physical state .....

reason .....

.....

[2]

(b) Aqueous chlorine reacts with aqueous sodium iodide.

(i) Complete the word equation for this reaction.

chlorine + sodium iodide → ..... + ...
.....

[2]

(ii) Explain why aqueous bromine does **not** react with aqueous sodium chloride.

..... [1]

(c) Fluorine reacts with water to produce hydrogen fluoride and oxygen.

Complete the symbol equation for this reaction.

$$2F_2 + ...H_2O \rightarrow 4HF + ...$$ [2]

(d) Name an anhydrous compound used to test for water.
State the colour of the compound after water is added.

name of compound .....

colour after water is added .....
[2]

[Total: 11]

6 This question is about metals.

(a) Metals are malleable and ductile.

State three **other** typical physical properties of metals.

1 .....

2 .....

3 .....

[3]

(b) (i) Complete Table 6.1 to show the number of electrons, neutrons and protons in the calcium atom and copper ion shown.

Table 6.1

	number of electrons	number of neutrons	number of protons
$^{48}_{20}Ca$	20		
$^{65}_{29}Cu^{2+}$		36	

[3]

(ii) Write the electronic configuration of the calcium atom.

..... [1]

(c) Copper is a transition element.

Choose the correct statement about transition elements.

Tick (✓) **one** box.

They have low densities. ☐

They often act as catalysts. ☐

They have low melting points. ☐

All their compounds are white. ☐

[1]

(d) Table 6.2 shows the observations when four different metals react with concentrated nitric acid.

Table 6.2

metal	observations with concentrated nitric acid
calcium	brown gas produced very rapidly
copper	brown gas produced slowly
manganese	brown gas produced rapidly
niobium	no brown gas seen

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive ⟶ most reactive

[2]

(e) Manganese(IV) oxide is reduced by aluminium.

$$3MnO_2 + 4Al \rightarrow 3Mn + 2Al_2O_3$$

Explain how this equation shows that manganese(IV) oxide is reduced.

..... [1]

[Total: 11]

7 This question is about acids, bases and salts.

(a) Crystals of zinc chloride can be made by warming excess solid zinc oxide with dilute hydrochloric acid.

$$ZnO(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(.....)$$

(i) Complete the symbol equation by adding the state symbol for water at room temperature. [1]

(ii) State the method used to separate the excess solid zinc oxide from the reaction mixture.

..... [1]

(iii) Describe how to make dry crystals of zinc chloride from an aqueous solution of zinc chloride.

.....

.....

.....

..... [2]

(b) Choose from the list the ion that is present in all acids.

Draw a circle around your chosen answer.

Cl^- **H^+** **O^{2-}** **OH^-** [1]

(c) The reaction of zinc oxide with hydrochloric acid is exothermic.

(i) Define the term exothermic.

..... [1]

(ii) Fig. 7.1 shows the incomplete reaction pathway diagram for the reaction of zinc oxide with hydrochloric acid.

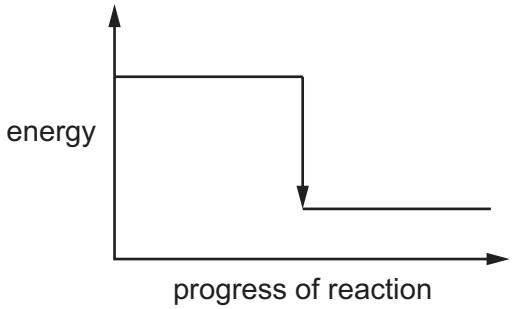

Fig. 7.1

Complete Fig. 7.1 by writing these formulae on the diagram:

- ZnO + 2HCl
- ZnCl_2 + H_2O. [1]

(iii) Explain how Fig. 7.1 shows that the reaction is exothermic.

..... [1]

(d) Litmus is an acid–base indicator.

State the colour of litmus at pH 2 and at pH 12.

colour at pH 2 .....

colour at pH 12 .....

[2]

[Total: 10]

8 **(a)** A student investigates the reaction of small pieces of magnesium oxide with excess dilute hydrochloric acid of three different concentrations.
The time taken for each reaction to finish is recorded.

The three concentrations of the acid are:
- 0.4 mol / dm^3
- 0.8 mol / dm^3
- 1.6 mol / dm^3.

All other conditions stay the same.

Table 8.1 shows the time taken for each reaction to finish.

Table 8.1

concentration of dilute hydrochloric acid in mol / dm^3	time taken for the reaction to finish in s
	160
	80
	320

(i) Complete Table 8.1 by writing the concentrations in the first column. [1]

(ii) Describe the effect on the time taken for the reaction to finish when the reaction is carried out at a lower temperature.

All other conditions stay the same.

..... [1]

(iii) Describe the effect on the time taken for the reaction to finish when large pieces of magnesium oxide are used instead of small pieces of magnesium oxide.

All other conditions stay the same.

..... [1]

(b) Molten magnesium chloride is electrolysed using inert electrodes.

(i) Name the products at the positive and negative electrodes.

product at the positive electrode .....

product at the negative electrode .....

[2]

(ii) Describe the arrangement, motion and separation of the particles in liquid magnesium chloride.

arrangement .....

.....

motion .....

.....

separation .....

.....

[3]

[Total: 8]

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.).