Cambridge Assessment International Education

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CHEMISTRY **0620/31**

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. Any blank pages are indicated.

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1 **(a)** Fig. 1.1 shows part of the Periodic Table.

View solution

I	II											III	IV	V	VI	VII	VIII
							H										
																F	
Na												Al		P	S	Cl	Ar
K	Ca								Ni							Br	
																I	

Fig. 1.1

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) produces a lilac colour in a flame test

..... [1]

(ii) has an atom with only two occupied electron shells

..... [1]

(iii) is an unreactive gas

..... [1]

(iv) forms an ion that gives a white precipitate after the addition of excess sodium hydroxide

..... [1]

(v) forms an ion with a charge of 2–

..... [1]

(vi) is added to iron to make stainless steel.

..... [1]

View solution

(b) Stainless steel is a mixture.

State **two** characteristics of a mixture.

1 .....

2 .....

[2]

[Total: 8]

Question 2 starts on the next page.

2 Nitrogen molecules are diatomic.

(a) (i) State the meaning of the term diatomic.

View solution

..... [1]

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

View solution

..... [1]

(b) Ammonia has a simple molecular structure.

View solution

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

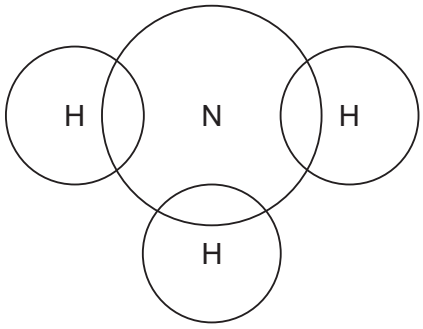

Fig. 2.1

[2]

(c) Sodium chloride has a giant ionic structure of positive and negative ions.

View solution

(i) State the general name given to any positive ion.

..... [1]

(ii) State **one** physical property of an ionic compound.

..... [1]

View solution

(d) Graphite is used as an electrode.

View solution

(i) State one **other** use of graphite.

..... [1]

View solution

(ii) Choose the correct statement that describes the structure and bonding in graphite.

Tick (✓) **one** box.

simple covalent molecule	☐
giant ionic	☐
simple ionic	☐
giant covalent	☐

[1]

[Total: 8]

3 **(a)** Polluted water can contain harmful substances such as plastics and phosphates.

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State two **other** types of harmful substance in polluted water.

1 .....

2 .....

[2]

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

View solution

Table 3.1

name of ion	formula of ion	mass of ion in 1000 cm^3 of polluted water / mg
ammonium	NH_4^+	0.6
bromide	Br^-	0.3
calcium	Ca^{2+}	2.5
chloride	Cl^-	2.5
hydrogencarbonate	HCO_3^-	12.0
magnesium	Mg^{2+}	0.8
	NO_3^-	0.4
phosphate	PO_4^{3-}	0.5
potassium	K^+	5.3
silicate	SiO_3^{2-}	3.0
sodium	Na^+	9.2
sulfate	SO_4^{2-}	0.5

Answer these questions using the information from Table 3.1.

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

..... [1]

(ii) State the name of the NO_3^- ion.

View solution

..... [1]

(iii) Calculate the mass of sodium ions in 250 cm^3 of polluted water.

View solution

mass = ... mg [1]

(c) Fig. 3.1 shows some of the stages in the treatment of the domestic water supply.

View solution

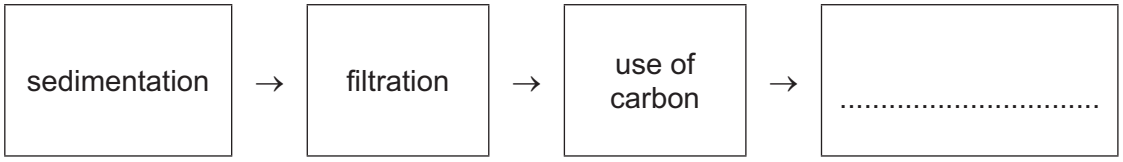

Fig. 3.1

(i) Complete Fig. 3.1 by adding the final stage. [1]

(ii) State why carbon is added to drinking water.

View solution

..... [1]

(d) Describe how to test the purity of water using melting point.

View solution

.....

.....

.....

..... [2]

(e) Complete the symbol equation for the reaction of phosphorus(V) chloride, PCl_5, with water.

$$2PCl_5 + 8H_2O \rightarrow .....H_3PO_4 + ...HCl$$ [2]

[Total: 11]

View solution

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

View solution

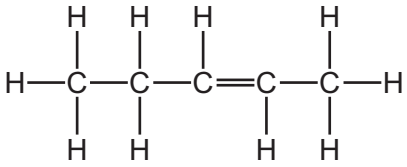

Fig. 4.1

(i) Explain why compound **A** is described as unsaturated.

.....

..... [1]

(ii) Explain why compound **A** is a hydrocarbon.

View solution

.....

..... [1]

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

View solution

..... [1]

(b) Compound **A** reacts with steam to produce an alcohol.

View solution

(i) State the general formula for the homologous series of alcohols.

..... [1]

(ii) Ethanol is an alcohol which can be manufactured by fermentation.

View solution

- Name **two** substances needed for fermentation.

1 .....

2 .....

- Give **two** conditions needed for fermentation.

1 .....

2 .....

[4]

(iii) State **one** use of ethanol.

..... [1]

View solution

(c) A compound in the same homologous series as compound **A** reacts with ozone, O_3, to form compound **B**.

View solution

(i) Define the term homologous series.

.....

..... [2]

View solution

(ii) The molecular formula for compound **B** is $C_6H_{12}O_3$.

Complete Table 4.1 to calculate the relative molecular mass of $C_6H_{12}O_3$.

Table 4.1

type of atom	number of atoms	relative atomic mass	
carbon	6	12	$6 \times 12 = 72$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

[Total: 13]

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

View solution

Table 5.1

halogen	melting point / °C	boiling point / °C	atomic radius / nm
fluorine	–220	–188	
chlorine	–101	–35	0.099
bromine	–7	+59	0.114
iodine		+184	0.133
astatine	+302	+337	0.155

Use the information in Table 5.1 to predict:

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

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

(iii) the physical state of bromine at 0 °C. Give a reason for your answer.

physical state .....

reason .....

.....

[2]

View solution

(b) Aqueous chlorine reacts with aqueous potassium iodide.

(i) Complete the word equation for this reaction.

chlorine	+	potassium iodide	→	.....	+	....

[2]

(ii) Explain why aqueous iodine does **not** react with aqueous potassium bromide.

..... [1]

View solution

(c) Fluorine reacts with hot concentrated sodium hydroxide to produce sodium fluoride, water and oxygen.

View solution

(i) Complete the symbol equation for this reaction.

$2F_2 + 4NaOH \rightarrow .....NaF + 2H_2O + ...$ [2]

View solution

(ii) Describe a test for oxygen.

test .....

observations .....

[2]

[Total: 11]

6 This question is about metals.

(a) Metals are good electrical conductors.

View solution

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 potassium atom and the nickel ion shown.

View solution

Table 6.1

	number of electrons	number of neutrons	number of protons
$^{41}_{19}K$	19		
$^{62}_{28}Ni^{2+}$		34	

[3]

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

View solution

..... [1]

(c) Choose **one** property from the list that shows that nickel is a transition element.

View solution

Tick (✓) **one** box.

has a low density	☐
forms coloured compounds	☐
has a low melting point	☐
does **not** act as a catalyst	☐

[1]

(d) Nickel can be manufactured by reducing nickel(II) oxide with carbon monoxide and hydrogen.

$$2NiO + CO + H_2 \rightarrow 2Ni + H_2O + CO_2$$

View solution

Explain how this equation shows that nickel(II) oxide is reduced.

..... [1]

(e) Table 6.2 shows the observations when four different metals are heated with steam.

View solution

Table 6.2

metal	observations with steam
chromium	forms an oxide layer slowly
copper	forms an oxide layer very slowly
magnesium	forms an oxide layer rapidly
niobium	does not form an oxide layer

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

least reactive → most reactive

[2]

[Total: 11]

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7 This question is about acids, bases and salts.

(a) Crystals of potassium chloride can be made by reacting an acid with an alkali.

View solution

(i) Name the acid and the alkali used.

acid .....

alkali .....

[2]

(ii) Choose from the list the type of reaction that takes place when an acid reacts with an alkali.

View solution

Draw a circle around your chosen answer.

addition **neutralisation** **redox** **substitution** [1]

View solution

(iii) Thymolphthalein is an acid–base indicator.

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

colour at pH 2 .....

colour at pH 12 .....

[2]

(iv) Describe how to make dry crystals of potassium chloride from an aqueous solution of potassium chloride.

.....

.....

.....

..... [2]

View solution

(b) Crystals of potassium chloride dissolve in water. This process is endothermic.

View solution

(i) Define the term endothermic.

.....

..... [1]

(ii) Fig. 7.1 shows the reaction pathway diagram for dissolving potassium chloride in water.

View solution

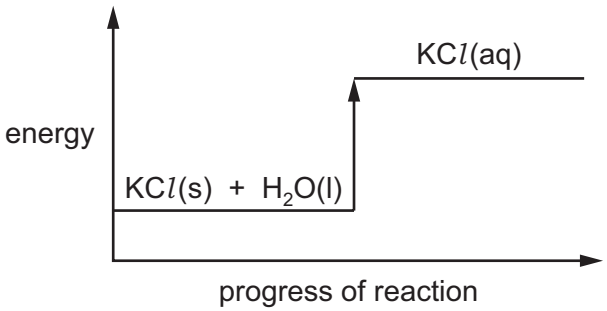

Fig. 7.1

Answer the following questions using the information in Fig. 7.1.

- State the meaning of the state symbol (l).

.....

- Explain how Fig. 7.1 shows that dissolving potassium chloride in water is endothermic.

.....

.....

[2]

[Total: 10]

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

View solution

The three concentrations of the acid are:

- $0.2\,mol/dm^3$
- $0.4\,mol/dm^3$
- $0.8\,mol/dm^3$.

All other conditions stay the same.

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

Table 8.1

concentration of dilute sulfuric acid in mol/dm^3	time taken for the reaction to finish in s
	92
	23
	46

(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 in the presence of a catalyst.

View solution

All other conditions stay the same.

..... [1]

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

View solution

All other conditions stay the same.

..... [1]

(b) Dilute sulfuric acid is electrolysed using inert electrodes.

View solution

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

product at the positive electrode .....

product at the negative electrode .....

[2]

View solution

(ii) Choose from the list the metal used as an inert electrode.

Draw a circle around your chosen answer.

calcium **magnesium** **platinum** **sodium** [1]

View solution

(c) Zinc is a solid at room temperature.

Describe the arrangement and separation of the particles in solid zinc.

arrangement .....

.....

separation .....

.....

[2]

[Total: 8]

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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.).