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CHEMISTRY**0620/33**

Paper 3 Theory (Core)

May/June 2025**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.



2

1 A list of substances is shown.

calcium
calcium oxide
carbon
carbon dioxide
chlorine
copper
gold
iodine
neon
nitrogen
oxygen
potassium
sulfur dioxide

Answer the following questions about these substances. Each substance may be used once, more than once or not at all.

State which substance is:

(a) an element which forms an ion with a 3– charge

..... [1]

(b) a transition element

..... [1]

(c) a gas that is identified using limewater

..... [1]

(d) approximately 78% of clean, dry air

..... [1]

(e) used in electrical wiring

..... [1]

(f) the least reactive metal in the list

..... [1]



(g) a diatomic molecule which is a solid at room temperature and pressure

..... [1]

(h) a compound that reacts with impurities in the blast furnace to form slag

..... [1]

(i) an element with a relative atomic mass of 12.

..... [1]

[Total: 9]



2 This question is about sea water and the substances found in sea water.

- (a) Table 2.1 shows the masses of the compounds present when a 2000 cm^3 sample of sea water is evaporated.

Table 2.1

compound	formula	mass of compound / g
sodium chloride	NaCl	28.0
	MgSO_4	5.5
potassium chloride	KCl	2.5
calcium carbonate	CaCO_3	2.0

Answer these questions using the information from Table 2.1.

- (i) State the chemical name of MgSO_4 .

..... [1]

- (ii) The total mass of compounds formed from 2000 cm^3 of sea water is 38.0 g. Calculate the total mass of compounds present in 800 cm^3 of sea water.

mass = g [1]

- (iii) Potassium chloride is soluble in water.

Choose **one other** compound that is soluble in water.

Tick (✓) **one** box.

lead(II) sulfate

☐

magnesium carbonate

☐

silver chloride

☐

sodium hydroxide

☐

[1]



(b) Potassium iodide is also found in sea water and contains iodide ions.

Describe a test for iodide ions.

test

.....

observations

.....

[2]

(c) Potassium chloride contains potassium ions.

Complete Fig. 2.1 to show:

- the electronic configuration of a potassium ion
- the charge on the ion.

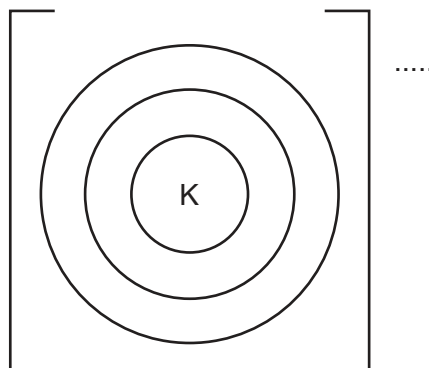


Fig. 2.1

[2]

(d) Sodium chloride is a solid at room temperature.

Describe the separation and motion of the particles in a solid.

separation

.....

motion

.....

[2]



- (e) Sea water contains dissolved phosphate ions.

State **one** source of phosphate ions.

..... [1]

- (f) Water is a simple molecular compound.

Complete the dot-and-cross diagram in Fig. 2.2 for a molecule of water.

Show outer electrons only.

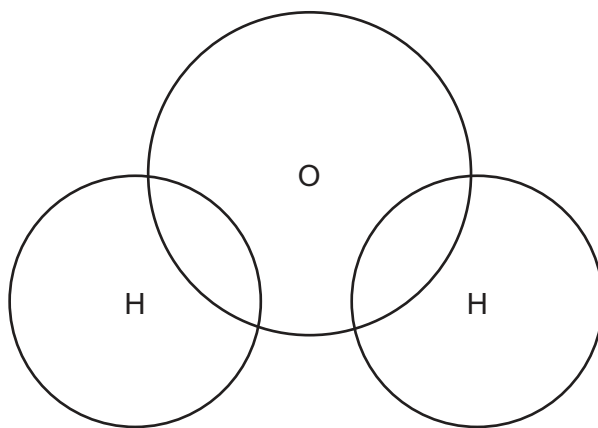


Fig. 2.2

[2]

[Total: 12]



3 This question is about organic chemistry.

(a) Petroleum is a mixture of hydrocarbons and is separated by fractional distillation in an industrial process.

(i) State which physical property of hydrocarbons allows them to be separated by fractional distillation.

..... [1]

(ii) Describe how petroleum is separated into fractions by fractional distillation.

.....

.....

..... [2]

(iii) Name the process that breaks down long chain hydrocarbon molecules to form short chain hydrocarbon molecules.

..... [1]

(iv) Some of the fractions obtained from petroleum are shown.

Draw a line from each fraction to its use.

fraction	use
bitumen	waxes and polishes
lubricating oil	making roads
naphtha	chemical feedstock

[2]



(b) Ethanoic acid is an organic molecule.

(i) Draw the displayed formula of a molecule of ethanoic acid.

[2]

(ii) Ethanoic acid reacts with sodium carbonate.

Name the salt produced in this reaction.

[1]

(c) Ethane is burned in excess oxygen.

Name the **two** products of this process.

[2]

(d) Ethanol is another organic molecule.

State **two** ways to manufacture ethanol.

1

2

[2]



(e) Fig. 3.1 shows the displayed formula of an organic molecule.

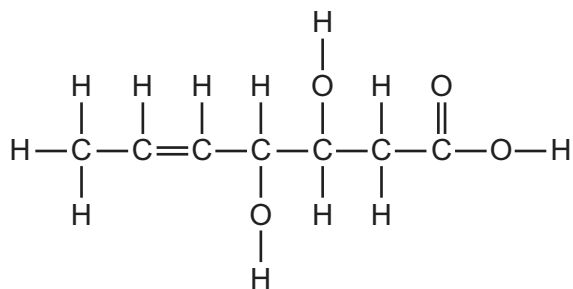


Fig. 3.1

- (i) Deduce the molecular formula of the molecule in Fig. 3.1.

..... [1]

- (ii) Explain why the molecule in Fig. 3.1 is unsaturated.

..... [1]

[Total: 15]



4 This question is about nitrogen and its compounds.

(a) (i) Explain why nitrogen is in Group V of the Periodic Table.

.....
 [1]

(ii) Two isotopes of nitrogen are shown in Fig. 4.1.



Fig. 4.1

Complete Table 4.1 to show the number of protons, neutrons and electrons in one atom of these isotopes.

Table 4.1

	protons	neutrons	electrons
${}^{14}_{7}\text{N}$			
${}^{15}_{7}\text{N}$			

[3]

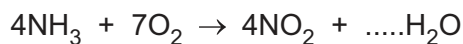
(b) Oxides of nitrogen are air pollutants.

(i) State **one** source of oxides of nitrogen in the air.

..... [1]

(ii) Ammonia reacts with oxygen to form nitrogen dioxide and water.

Complete the symbol equation for this reaction.



[1]

(iii) State the type of bonding between the atoms in nitrogen dioxide.

..... [1]



(iv) State whether nitrogen dioxide is an acidic or basic oxide.

Give a reason for your answer.

.....
..... [1]

(c) A compound of nitrogen has the formula $\text{Al}(\text{NO}_3)_3$.

Complete Table 4.2 to calculate the relative formula mass of $\text{Al}(\text{NO}_3)_3$.

Table 4.2

atom	number of atoms	relative atomic mass	
oxygen	9	16	$9 \times 16 = 144$
aluminium		27	
nitrogen		14	

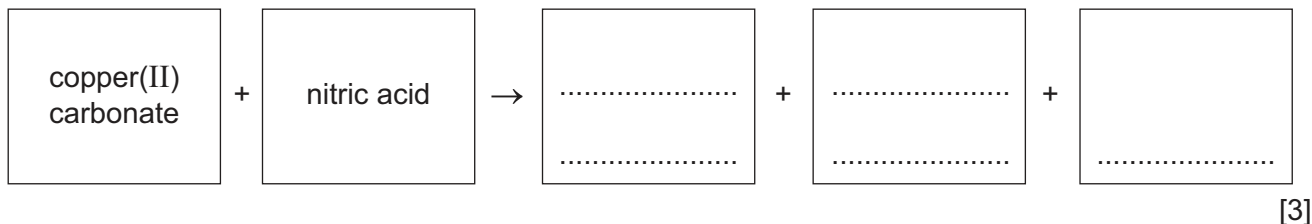
relative formula mass = [2]

[Total: 10]



5 This question is about ionic compounds and simple molecular compounds.

(a) Complete the word equation to show the reaction between copper(II) carbonate and nitric acid.



(b) Aqueous magnesium chloride is prepared by adding excess magnesium oxide powder to dilute hydrochloric acid.

Describe how to prepare a sample of pure, dry magnesium chloride crystals **after** the reaction is complete.

In your answer describe how to:

- remove the excess magnesium oxide from the reaction mixture
- crystallise the magnesium chloride
- dry the crystals.

.....

.....

.....

.....

.....

.....

[3]

(c) Fig. 5.1 shows the apparatus for the electrolysis of molten cobalt(II) bromide using inert electrodes.

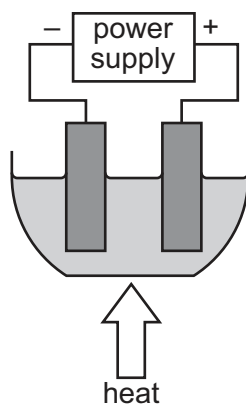


Fig. 5.1

(i) Label Fig. 5.1 to show the:

- anode
- electrolyte.



(ii) Name the products formed at the positive and negative electrodes.

positive electrode

negative electrode

[2]

(d) Table 5.1 shows some properties of five compounds, **A**, **B**, **C**, **D** and **E**.

Table 5.1

compound	electrical conductivity when molten	density in g/cm ³	melting point in °C
A	conducts	1.85	115
B	does not conduct	2.65	1713
C	does not conduct	0.42	−182
D	conducts	2.99	1190
E	does not conduct	1.56	−101

State which **two** of the compounds, **A**, **B**, **C**, **D** and **E**, are simple molecules.

Give **two** reasons for your answer.

compounds and

reason 1

reason 2

[3]

[Total: 13]



6 This question is about chemical reactions and their energy changes.

(a) Tick (✓) **one** box that shows a chemical change.

boiling ethanol

☐

decomposing vegetation

☐

dissolving salt

☐

mixing ink and water

☐

[1]

(b) Table 6.1 shows the results of four experiments.

Table 6.1

experiment	initial temperature / °C	final temperature / °C
1	20	14
2	18	26
3	19	25
4	17	12

(i) State which experiment shows the greatest temperature change.

..... [1]

(ii) State which experiment is the most endothermic.

..... [1]



(iii) Fig. 6.1 shows an incomplete reaction pathway diagram for an exothermic reaction.

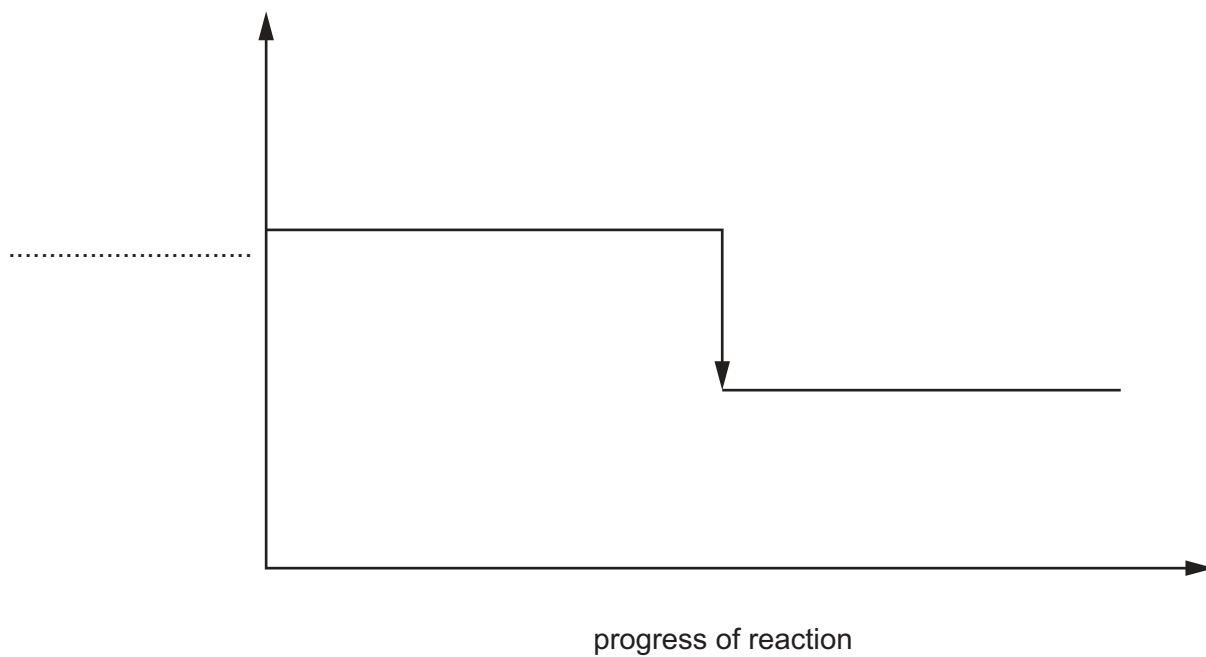


Fig. 6.1

Complete Fig. 6.1 by labelling:

- the vertical axis
- the reactants
- the products.

[2]

[Total: 5]



7 This question is about air and water.

(a) Water needs to be treated to make it safe to drink.

Complete Fig. 7.1 to show the three stages needed in the treatment of domestic water. The second stage has been completed.

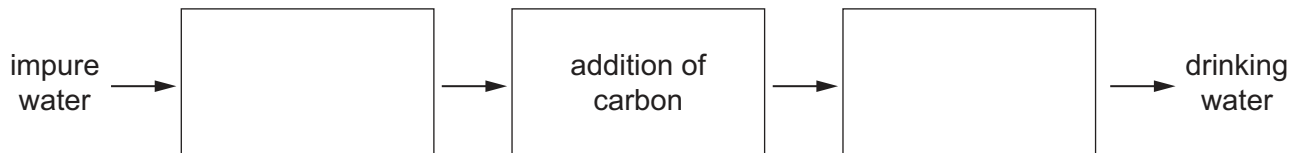


Fig. 7.1

[2]

(b) Describe a chemical test for the presence of water.

test

.....

observations

.....

[2]

(c) A sample of air contains carbon dioxide and oxides of nitrogen.

State **one** harmful effect of each of these air pollutants.

carbon dioxide

oxides of nitrogen

[2]

[Total: 6]



8 This question is about metals.

- (a) (i) A student investigates the reaction of four different metals, **A**, **B**, **C** and **D**, with dilute sulfuric acid.

All other conditions are the same.

The results of the experiments are shown in Table 8.1.

Table 8.1

metal	observations
A	lots of bubbles at room temperature
B	no bubbles
C	few bubbles on warming
D	lots of bubbles on warming

Put the metals, **A**, **B**, **C** and **D**, in order of their reactivity.

most reactive



least reactive

[1]

- (ii) Increasing the temperature of the acid increases the rate of reaction.

State **two other** ways to increase the rate of this reaction.

1

.....

2

.....

[2]



(b) In another experiment, a student adds lithium to water. An alkaline solution is formed.

(i) State the colour seen in the flame test for lithium ions.

..... [1]

(ii) State the ion that all aqueous alkalis contain.

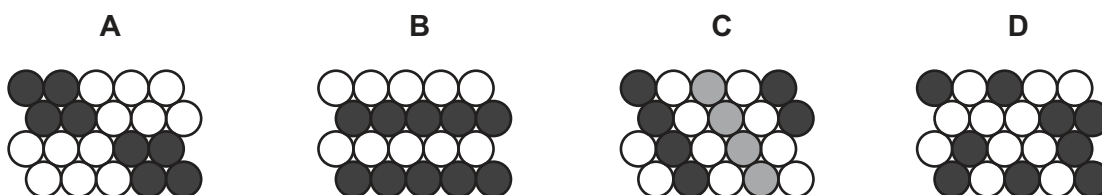
..... [1]

(iii) State the colour of thymolphthalein in an aqueous alkali.

..... [1]

(c) Pewter is an alloy that contains tin.

(i) State which **one** of these diagrams, **A**, **B**, **C** or **D**, best represents an alloy.



..... [1]

(ii) Suggest **one** property of pewter that makes it more useful than pure tin.

..... [1]

(d) Metals are good thermal conductors.

Describe **two other** physical properties that are typical of metals.

1

2

[2]

[Total: 10]



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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
		1 H hydrogen 1															
		Key atomic number atomic symbol name relative atomic mass															
3	4																
Li lithium 7	Be beryllium 9																
11	12																
Na sodium 23	Mg magnesium 24																
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59	Cu copper 64	Zn zinc 65	Ga gallium 70	Ge germanium 73	As arsenic 75	Se selenium 79	Br bromine 80	Kr krypton 84
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium —	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106	Ag silver 108	Cd cadmium 112	In indium 115	Sn tin 119	Sb antimony 122	Te tellurium 128	I iodine 127	Xe xenon 131
55	56	57–71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs caesium 133	Ba barium 137	lanthanoids	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Hg mercury 201	Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —
87	88	89–103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Nh nihonium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessine —	Og oganesson —

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

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

