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**CHEMISTRY****0620/31**

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.



1 A list of substances is shown.

aluminium  
ammonia  
argon  
bromine  
carbon dioxide  
fluorine  
iron  
magnesium  
magnesium chloride  
nitrogen  
oxygen  
potassium

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 1+ charge

..... [1]

(b) a metal that is extracted in the blast furnace

..... [1]

(c) a soft metal that is more reactive than sodium

..... [1]

(d) approximately 78% of clean, dry air

..... [1]

(e) a gas that is identified using damp red litmus paper

..... [1]

(f) a liquid at room temperature and pressure

..... [1]

(g) an element used in food containers because of its resistance to corrosion

..... [1]

(h) a transition element.

..... [1]

[Total: 8]



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

- (a) Table 2.1 shows the masses of the compounds formed when  $1000\text{ cm}^3$  of sea water is evaporated.

Table 2.1

| compound           | formula         | mass of compound / g |
|--------------------|-----------------|----------------------|
| sodium chloride    | $\text{NaCl}$   | 14.0                 |
| magnesium sulfate  | $\text{MgSO}_4$ | 3.0                  |
| potassium chloride | $\text{KCl}$    | 1.0                  |
|                    | $\text{CaCO}_3$ | 1.0                  |

Answer these questions, using the information from Table 2.1.

- (i) State the chemical name of  $\text{CaCO}_3$ .

..... [1]

- (ii) The total mass of compounds formed from  $1000\text{ cm}^3$  of sea water is 19.0 g.

Calculate the total mass of compounds formed from  $1750\text{ cm}^3$  of sea water.

mass = ..... g [1]

- (iii) Magnesium sulfate is soluble in water.

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

Tick (✓) **one** box.

lead(II) chloride

☐

magnesium carbonate

☐

potassium hydroxide

☐

silver chloride

☐

[1]



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

Describe a test for chloride ions.

test .....

.....

observations .....

.....

[2]

(c) Sodium ions are in sea water.

Complete Fig. 2.1 to show:

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

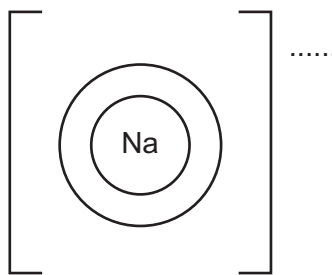


Fig. 2.1

[2]

(d) Sodium chloride forms a liquid when heated.

Describe the arrangement and motion of the particles in a liquid.

arrangement .....

.....

motion .....

.....

[2]

(e) Sodium chloride is an ionic compound that dissolves in water.

State **two other** properties of an ionic compound.

1 .....

2 .....

[2]



\* 0000800000005 \*



5

(f) Sea water contains dissolved gases.

Name the gas that is essential for aquatic life.

..... [1]

[Total: 12]



3 This question is about sulfur and its compounds.

(a) (i) Explain why sulfur is placed in Group VI of the Periodic Table.

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

(ii) Two isotopes of sulfur are shown in Fig. 3.1.



Fig. 3.1

Complete Table 3.1 to show the number of protons, neutrons and electrons in one atom of these isotopes.

Table 3.1

|                        | protons | neutrons | electrons |
|------------------------|---------|----------|-----------|
| ${}^{33}_{16}\text{S}$ |         |          |           |
| ${}^{36}_{16}\text{S}$ |         |          |           |

[3]

(b) Sulfur dioxide is an air pollutant.

(i) State **one** source of sulfur dioxide in the air.

..... [1]

(ii) State **one** adverse effect on the environment of sulfur dioxide.

..... [1]

(iii) Sulfur dioxide reacts with hydrogen sulfide.

Complete the symbol equation for this reaction.



(iv) State the type of bonding between the atoms in sulfur dioxide.

..... [1]





(c) A compound of sulfur has the formula  $Al_2(SO_4)_3$ .

Complete Table 3.2 to calculate the relative formula mass of  $Al_2(SO_4)_3$ .

**Table 3.2**

| atom      | number of atoms | relative atomic mass |                      |
|-----------|-----------------|----------------------|----------------------|
| oxygen    | 12              | 16                   | $12 \times 16 = 192$ |
| aluminium |                 | 27                   |                      |
| sulfur    |                 | 32                   |                      |

relative formula mass = .....  
[2]

[Total: 11]



4 This question is about organic chemistry.

(a) (i) Name the process that separates petroleum into its useful components.

..... [1]

(ii) Fuel oil is obtained from petroleum.

State **one** use of fuel oil.

..... [1]

(iii) Natural gas is a fossil fuel.

Draw a circle around **one** compound that is the main constituent of natural gas.

**carbon dioxide      ethane      ethanol      methane** [1]

(b) (i) Describe how long chain hydrocarbon molecules can be made into short chain molecules.

Include in your answer:

- the name of this process
- the conditions needed for this process to take place
- the products of this process.

.....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....  
 ..... [4]

(ii) State **one** reason why long chain hydrocarbon molecules are made into short chain hydrocarbon molecules.

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





(c) Draw the displayed formula of a molecule of ethane.

[1]

(d) (i) Ethanol is manufactured by fermentation of aqueous glucose.

State **two** conditions for fermentation.

1 .....

2 ..... [2]

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

..... [1]

(e) Fig. 4.1 shows the displayed formula of an organic molecule.

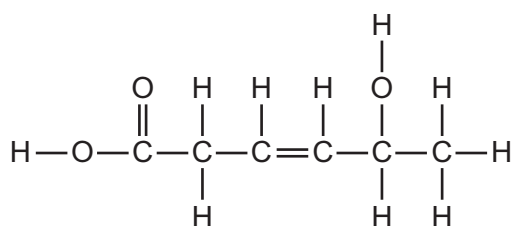


Fig. 4.1

(i) Deduce the molecular formula of this molecule.

..... [1]

(ii) Explain why the molecule in Fig. 4.1 is unsaturated.

..... [1]

[Total: 14]



5 This question is about metals and their reactions.

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

All other conditions are the same in each test-tube.

The results of the experiment are shown in Fig. 5.1.

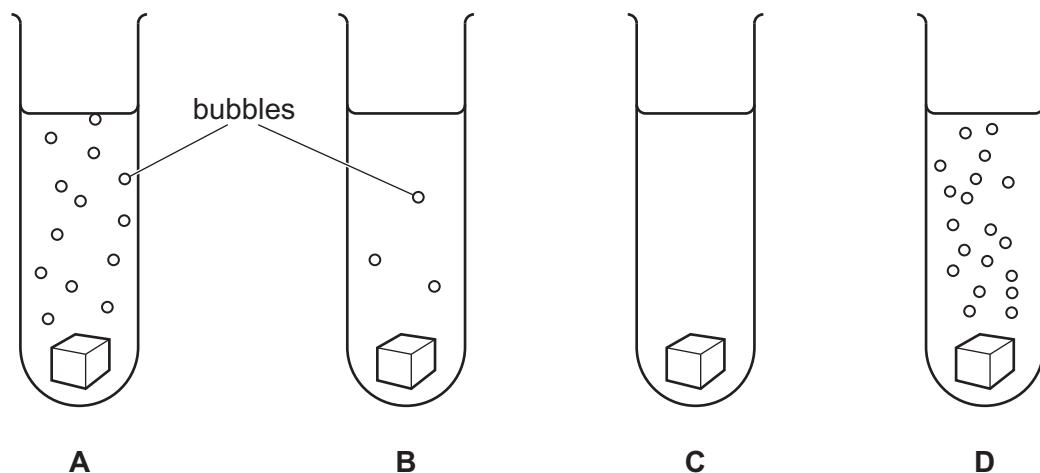


Fig. 5.1

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

most reactive .....  
 .....  
 .....  
 .....  
 ↓  
 least reactive .....

[1]

- (ii) One way the student can increase the rate of the reaction in the experiment is to use a higher concentration of acid.

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

1 .....

2 .....

[2]

- (iii) Hydrogen gas is produced in this experiment.

Describe a test for hydrogen gas.

test .....

observations .....

.....

[1]





(iv) State the formula of the ion that is present in all acids.

..... [1]

(b) Stainless steel is an alloy.

(i) State the meaning of the term alloy.

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

(ii) State **one** property of stainless steel that makes it suitable for cutlery.

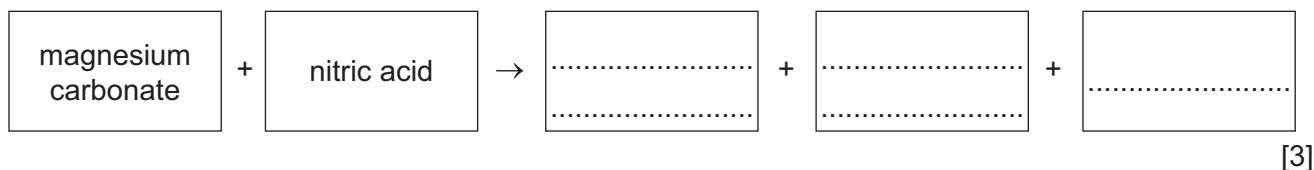
..... [1]

[Total: 7]



6 This question is about ionic and covalent compounds.

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



(b) Crystals of copper(II) chloride are prepared by adding excess copper(II) oxide powder to dilute hydrochloric acid.

Describe how to prepare a sample of pure, dry copper(II) chloride crystals **after** the reaction is complete.

In your answer, describe how to:

- remove the excess copper(II) oxide from the reaction mixture
- crystallise the copper(II) chloride
- dry the crystals.

.....

.....

.....

.....

.....

..... [3]

(c) (i) Fig. 6.1 shows the apparatus for the electrolysis of molten lithium iodide, using inert electrodes.

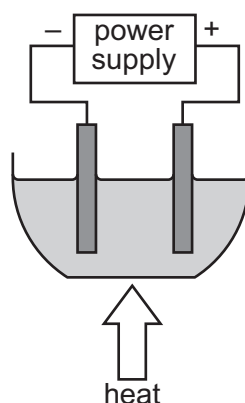


Fig. 6.1

Label Fig. 6.1 to show the:

- anode
- molten lithium iodide.





- (ii) Platinum metal is used as an inert electrode in this electrolysis experiment.

Name **one other** suitable material that can be used as an inert electrode.

..... [1]

- (iii) Name the products formed at the positive and negative electrodes when molten lithium iodide is electrolysed.

positive electrode .....

negative electrode .....

[2]

- (d) Table 6.2 shows some properties of five compounds, **A**, **B**, **C**, **D** and **E**.

**Table 6.2**

| compound | electrical conductivity<br>when molten | density in g/cm <sup>3</sup> | melting point in °C |
|----------|----------------------------------------|------------------------------|---------------------|
| <b>A</b> | does not conduct                       | 3.53                         | 1856                |
| <b>B</b> | does not conduct                       | 1.57                         | –157                |
| <b>C</b> | conducts                               | 1.93                         | 110                 |
| <b>D</b> | conducts                               | 3.03                         | 1256                |
| <b>E</b> | does not conduct                       | 4.93                         | –83                 |

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: 14]



7 This question is about energy changes in reactions.

(a) Table 7.1 shows the results of four experiments.

**Table 7.1**

| experiment | initial temperature / °C | final temperature / °C |
|------------|--------------------------|------------------------|
| 1          | 17                       | 23                     |
| 2          | 21                       | 13                     |
| 3          | 18                       | 14                     |
| 4          | 19                       | 26                     |

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

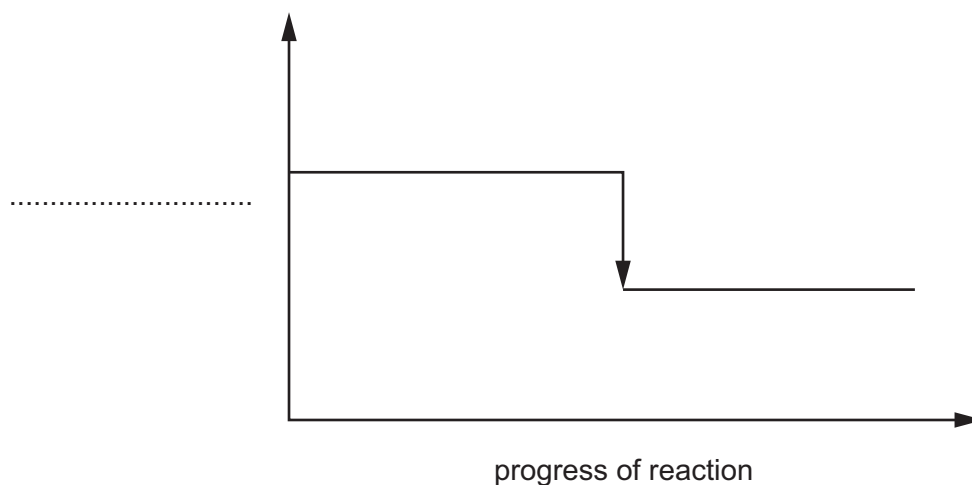
..... [1]

(ii) In experiment 4, zinc was added to dilute hydrochloric acid.

Complete the symbol equation.



(iii) Fig. 7.1 shows the incomplete reaction pathway diagram for the reaction in Experiment 4.



**Fig. 7.1**

Complete Fig. 7.1 by labelling:

- the vertical axis
- the reactants
- the products.

[2]





(b) Fig. 7.2 shows the changes of state of copper.

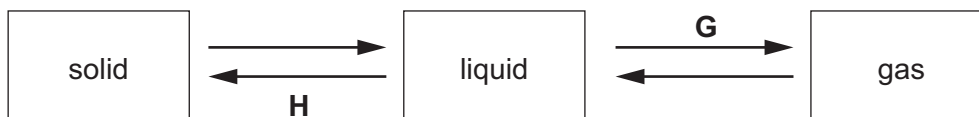


Fig. 7.2

Name the changes of state labelled **G** and **H**.

**G** .....

**H** .....

[2]

[Total: 7]



8 This question is about water and air.

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

Two of the stages used in the treatment of domestic water are the addition of carbon and chlorination.

Describe the reason for each of these stages.

addition of carbon .....

.....

chlorination .....

.....

[2]

(b) Describe how to test whether a sample of water is pure using boiling point.

.....

.....

..... [2]

(c) Explain why distilled water is used in practical chemistry rather than tap water.

.....

..... [1]

(d) A sample of polluted air contains carbon monoxide and methane.

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

carbon monoxide .....

methane .....

[2]

[Total: 7]



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The Periodic Table of Elements

| Group                |                       |  |                                                                |  |                          |                       |                        |                       |                        |                       |                         |                        |                        |                       |                       |                       |                        |                        |                     |      |    |    |    |    |    |    |    |    |    |
|----------------------|-----------------------|--|----------------------------------------------------------------|--|--------------------------|-----------------------|------------------------|-----------------------|------------------------|-----------------------|-------------------------|------------------------|------------------------|-----------------------|-----------------------|-----------------------|------------------------|------------------------|---------------------|------|----|----|----|----|----|----|----|----|----|
| I                    | II                    |  | Key                                                            |  |                          |                       |                        |                       |                        |                       |                         |                        |                        |                       | III                   | IV                    | V                      | VI                     | VII                 | VIII |    |    |    |    |    |    |    |    |    |
|                      |                       |  | atomic number<br>atomic symbol<br>name<br>relative atomic mass |  |                          |                       |                        |                       |                        |                       |                         |                        |                        |                       |                       |                       |                        |                        |                     |      |    |    |    |    |    |    |    |    |    |
| 1                    | 2                     |  | 3                                                              |  |                          |                       |                        |                       |                        |                       |                         |                        |                        |                       | 4                     | 5                     | 6                      | 7                      | 8                   | 9    | 10 |    |    |    |    |    |    |    |    |
| Li<br>lithium<br>7   | Be<br>beryllium<br>9  |  | B<br>boron<br>11                                               |  |                          |                       |                        |                       |                        |                       |                         |                        |                        |                       | C<br>carbon<br>12     | N<br>nitrogen<br>14   | O<br>oxygen<br>16      | F<br>fluorine<br>19    | Ne<br>neon<br>20    |      |    |    |    |    |    |    |    |    |    |
| 11                   | 12                    |  | 13                                                             |  |                          |                       |                        |                       |                        |                       |                         |                        |                        |                       | 14                    | 15                    | 16                     | 17                     | 18                  |      |    |    |    |    |    |    |    |    |    |
| Na<br>sodium<br>23   | Mg<br>magnesium<br>24 |  | Al<br>aluminium<br>27                                          |  |                          |                       |                        |                       |                        |                       |                         |                        |                        |                       | Si<br>silicon<br>28   | P<br>phosphorus<br>31 | S<br>sulfur<br>32      | Cl<br>chlorine<br>35.5 | Ar<br>argon<br>40   |      |    |    |    |    |    |    |    |    |    |
| 19                   | 20                    |  | 21                                                             |  |                          |                       |                        |                       |                        |                       |                         |                        |                        |                       | 22                    | 23                    | 24                     | 25                     | 26                  | 27   | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| K<br>potassium<br>39 | Ca<br>calcium<br>40   |  | Sc<br>scandium<br>45                                           |  | Ti<br>titanium<br>48     | V<br>vanadium<br>51   | Cr<br>chromium<br>52   | Mn<br>manganese<br>55 | Fe<br>iron<br>56       | Co<br>cobalt<br>59    | Ni<br>nickel<br>59      | Cu<br>copper<br>64     | Zn<br>zinc<br>65       | Ga<br>gallium<br>70   | Ge<br>germanium<br>73 | As<br>arsenic<br>75   | Se<br>selenium<br>79   | Br<br>bromine<br>80    | Kr<br>krypton<br>84 |      |    |    |    |    |    |    |    |    |    |
| 37                   | 38                    |  | 39                                                             |  | 40                       | 41                    | 42                     | 43                    | 44                     | 45                    | 46                      | 47                     | 48                     | 49                    | 50                    | 51                    | 52                     | 53                     | 54                  |      |    |    |    |    |    |    |    |    |    |
| Rb<br>rubidium<br>85 | Sr<br>strontium<br>88 |  | Y<br>yttrium<br>89                                             |  | Zr<br>zirconium<br>91    | Nb<br>niobium<br>93   | Mo<br>molybdenum<br>96 | Tc<br>technetium<br>— | Ru<br>ruthenium<br>101 | Rh<br>rhodium<br>103  | Pd<br>palladium<br>106  | Ag<br>silver<br>108    | Cd<br>cadmium<br>112   | In<br>indium<br>115   | Sn<br>tin<br>119      | Sb<br>antimony<br>122 | Te<br>tellurium<br>128 | I<br>iodine<br>127     | Xe<br>xenon<br>131  |      |    |    |    |    |    |    |    |    |    |
| 55                   | 56                    |  | 57–71                                                          |  | 72                       | 73                    | 74                     | 75                    | 76                     | 77                    | 78                      | 79                     | 80                     | 81                    | 82                    | 83                    | 84                     | 85                     | 86                  |      |    |    |    |    |    |    |    |    |    |
| Cs<br>caesium<br>133 | Ba<br>barium<br>137   |  | lanthanoids                                                    |  | Hf<br>hafnium<br>178     | Ta<br>tantalum<br>181 | W<br>tungsten<br>184   | Re<br>rhenium<br>186  | Os<br>osmium<br>190    | Ir<br>iridium<br>192  | Pt<br>platinum<br>195   | Au<br>gold<br>197      | Hg<br>mercury<br>201   | Tl<br>thallium<br>204 | Pb<br>lead<br>207     | Bi<br>bismuth<br>209  | Po<br>polonium<br>—    | At<br>astatine<br>—    | Rn<br>radon<br>—    |      |    |    |    |    |    |    |    |    |    |
| 87                   | 88                    |  | 89–103                                                         |  | 104                      | 105                   | 106                    | 107                   | 108                    | 109                   | 110                     | 111                    | 112                    | 113                   | 114                   | 115                   | 116                    | 117                    | 118                 |      |    |    |    |    |    |    |    |    |    |
| Fr<br>francium<br>—  | Ra<br>radium<br>—     |  | actinoids                                                      |  | Rf<br>rutherfordium<br>— | Db<br>dubnium<br>—    | Sg<br>seaborgium<br>—  | Bh<br>bohrium<br>—    | Hs<br>hassium<br>—     | Mt<br>meitnerium<br>— | Ds<br>darmstadtium<br>— | Rg<br>roentgenium<br>— | Cn<br>copernicium<br>— | Nh<br>nihonium<br>—   | Fl<br>flerovium<br>—  | Mc<br>moscovium<br>—  | Lv<br>livermorium<br>— | Ts<br>tennessine<br>—  | Og<br>oganeson<br>— |      |    |    |    |    |    |    |    |    |    |

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).