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CHEMISTRY

0620/33

Paper 3 Theory (Core)

May/June 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 **20** pages. Any blank pages are indicated.

1 Fig. 1.1 shows part of the Periodic Table.

| | | | | | | | | | | | | | | | | |
|--|----|----|--|--|----|----|--|--|----|--|-----|----|---|----|-----|------|
| | I | II | | | | | | | | | III | IV | V | VI | VII | VIII |
| | Li | | | | | | | | | | | C | N | O | F | |
| | | | | | | | | | | | Al | | | | | Ar |
| | | Ca | | | Cr | Fe | | | Cu | | | | | | 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:

(a) is present in diamond

..... [1]

(b) forms an oxide that contributes to acid rain

..... [1]

(c) has an atom with five occupied electron shells

..... [1]

(d) forms an ion with a charge of 1+

..... [1]

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

..... [1]

(f) is used in the manufacture of aircraft because of its low density.

..... [1]

[Total: 6]

- 2 (a) Table 2.1 shows some properties of the halogens.

Table 2.1

| halogen | melting point in °C | boiling point in °C | density at room temperature and pressure in g/cm ³ |
|----------|------------------------|------------------------|---|
| fluorine | -220 | -188 | |
| chlorine | -101 | | 0.003 |
| bromine | -7 | +59 | 3.12 |
| iodine | +114 | +184 | 4.93 |

Use the information in Table 2.1 to predict:

- (i) the boiling point of chlorine [1]
- (ii) the density of fluorine at room temperature and pressure [1]
- (iii) the physical state of iodine at +100°C. Give a reason for your answer.

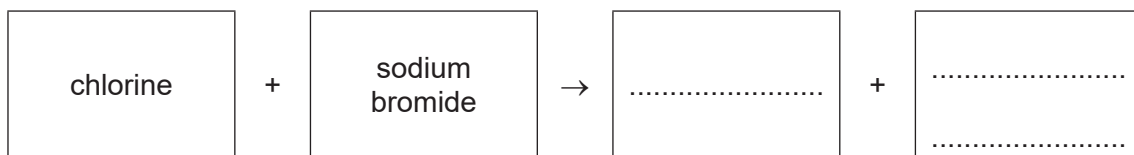
physical state

reason

..... [2]

- (b) Aqueous chlorine reacts with aqueous sodium bromide.

- (i) Complete the word equation for this reaction.



[2]

- (ii) State a test for sodium ions.

test

observations

[2]

[Total: 8]

3 (a) Polluted water can contain harmful substances such as metal compounds, nitrates and sewage.

(i) Name two **other** substances present in polluted water which are harmful to aquatic life.

1

2

[2]

(ii) State why sewage can cause disease.

..... [1]

(b) Table 3.1 shows the masses of ions, in mg, present in 1000 cm³ of polluted water.

Table 3.1

| name of ion | formula of ion | mass of ion present in mg / 1000 cm ³ of polluted water |
|-------------------|--------------------------------|--|
| ammonium | NH ₄ ⁺ | 1.2 |
| calcium | Ca ²⁺ | 2.2 |
| chloride | Cl ⁻ | 2.5 |
| hydrogencarbonate | HCO ₃ ⁻ | 13.0 |
| magnesium | Mg ²⁺ | 1.0 |
| nickel(II) | Ni ²⁺ | 0.2 |
| nitrate | NO ₃ ⁻ | 0.4 |
| potassium | K ⁺ | 6.3 |
| silicate | SiO ₃ ²⁻ | 8.0 |
| sodium | Na ⁺ | 12.2 |
| | SO ₄ ²⁻ | 0.1 |

Answer these questions using information from Table 3.1.

(i) Name the positive ion present in the lowest concentration.

..... [1]

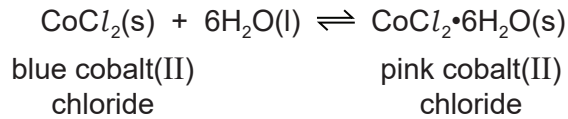
(ii) State the name of the ion SO₄²⁻.

..... [1]

(iii) Calculate the mass of calcium ions present in 250 cm³ of polluted water.

mass = mg [1]

(c) Cobalt(II) chloride can be used to test for the presence of water.



(i) Describe how pink cobalt(II) chloride can be changed to blue cobalt(II) chloride.

..... [1]

(ii) Choose a word from the list which best describes pink cobalt(II) chloride.

Draw a circle around your chosen answer.

anhydrous hydrated liquid reduced [1]

(d) Iron reacts with steam to form Fe_3O_4 and a gas which pops with a lighted splint.

Complete the symbol equation for this reaction.



[Total: 10]

4 This question is about bromine and compounds of bromine.

(a) Deduce the number of protons, neutrons and electrons in the bromide ion shown.



number of protons

number of neutrons

number of electrons

[3]

(b) Hydrogen bromide decomposes to hydrogen and bromine when heated.

Fig. 4.1 shows an incomplete reaction pathway diagram for this reaction.

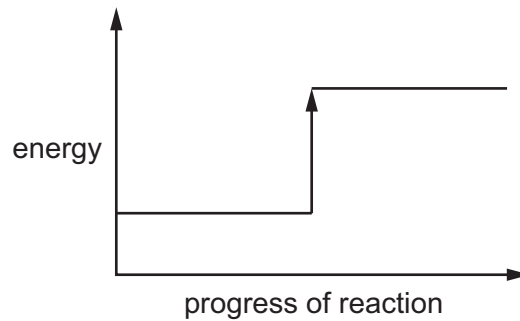


Fig. 4.1

(i) Complete Fig. 4.1 by writing these formulae on the diagram:

- 2HBr
- $\text{H}_2 + \text{Br}_2$.

[1]

(ii) Explain how Fig. 4.1 shows that the reaction is endothermic.

.....

[1]

(iii) Complete this sentence about an endothermic reaction using a word from the list.

products reactants bromine surroundings

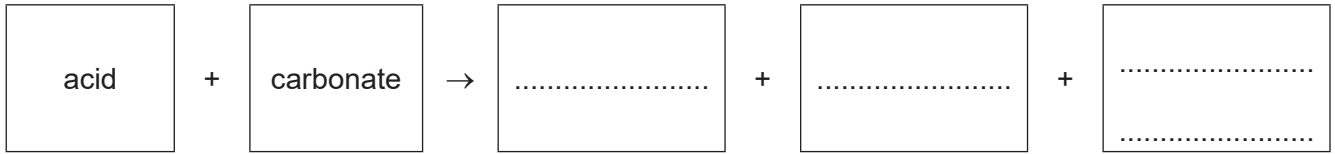
An endothermic reaction transfers thermal energy from the [1]

(c) Hydrobromic acid is formed when hydrogen bromide dissolves in water.

(i) Write the formula of the ion which is present in all acids.

..... [1]

(ii) Complete the word equation for the reaction of any acid with any carbonate.



[3]

(iii) A few drops of litmus indicator are added to a dilute acid.

State the colour of the solution.

..... [1]

- (d) Fig. 4.2 shows the apparatus used for the electrolysis of molten lead(II) bromide using graphite electrodes.

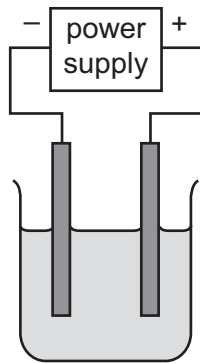


Fig. 4.2

- (i) Label Fig. 4.2 to show:

- the cathode
- the electrolyte.

[2]

- (ii) Name the products and state the observations at the positive and negative electrodes.

product at the positive electrode

.....

observations at the positive electrode

.....

product at the negative electrode

.....

observations at the negative electrode

.....

[4]

- (iii) State **one** property of graphite that makes it useful as an electrode.

..... [1]

[Total: 18]

5 This question is about metals.

(a) Nickel is a transition element. Sodium is an element in Group I of the Periodic Table.

State **two** differences in the physical properties of nickel compared to sodium.

1

2

[2]

(b) Stainless steel is an alloy that is used to make cutlery.

Give **one** reason why stainless steel is used to make cutlery.

..... [1]

(c) Table 5.1 shows some information about the reaction of four metals with oxygen.

Table 5.1

| metal | reaction with oxygen |
|-----------|--|
| gold | no reaction |
| lanthanum | forms a layer of oxide rapidly but does not burn |
| magnesium | burns rapidly to form an oxide |
| nickel | forms a layer of oxide slowly but does not burn |

Put the four metals in order of their reactivity.

Put the least reactive metal first.

least reactive \longrightarrow most reactive

| | | | |
|--|--|--|--|
| | | | |
|--|--|--|--|

[2]

(d) Complete the diagram in Fig. 5.1 to show the electronic configuration of a magnesium atom.

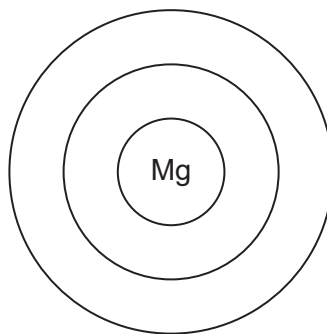


Fig. 5.1

[1]

[Total: 6]

- 6 (a) A student investigates the reaction of magnesium with dilute hydrochloric acid at three different temperatures.

The temperatures are:

- 20 °C
- 30 °C
- 40 °C.

All other conditions stay the same.

Table 6.1 shows the time taken for each reaction to finish.

Table 6.1

| temperature /°C | time taken for the reaction to finish/s |
|-----------------|---|
| | 45 |
| | 210 |
| | 95 |

- (i) Complete Table 6.1 by writing the temperatures in the first column. [1]

- (ii) Describe the effect on the time taken for the magnesium to finish reacting with dilute hydrochloric acid when the surface area of the magnesium is increased.

All other conditions stay the same.

..... [1]

- (iii) Describe the effect on the time taken for the magnesium to finish reacting with dilute hydrochloric acid when the concentration of acid is decreased.

All other conditions stay the same.

..... [1]

- (b) Describe how crystals of magnesium chloride can be prepared after reacting excess magnesium with dilute hydrochloric acid.

.....

 [2]

(c) Magnesium chloride is soluble in water.

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

Tick (✓) **one** box.

ammonium sulfate

calcium carbonate

iron(II) hydroxide

silver chloride

[1]

[Total: 6]

7 (a) Fig. 7.1 shows the displayed formula of compound **E**.

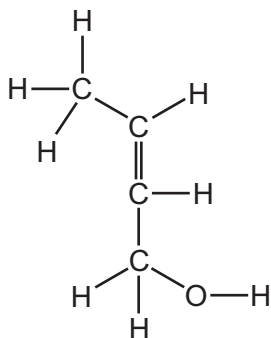


Fig. 7.1

(i) On Fig. 7.1 draw a circle around the functional group that makes compound **E** unsaturated. [1]

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

..... [1]

(iii) Describe a chemical test to distinguish between a saturated and an unsaturated compound.

test

observations with saturated compound

.....

observations with unsaturated compound

.....

[3]

(b) Alcohols have an -OH functional group.

(i) Write the general formula for the alcohol homologous series.

..... [1]

- (ii) Ethanol is an alcohol with two carbon atoms in each molecule.

Draw the displayed formula of ethanol.

[1]

- (c) Ethanol reacts to form a compound with the formula $C_6H_{12}O_2$.

Complete Table 7.1 to calculate the relative molecular mass of $C_6H_{12}O_2$.

Table 7.1

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

relative molecular mass = [2]

- (d) Ethanol can be manufactured by the fermentation of aqueous glucose.

State **two** conditions for fermentation.

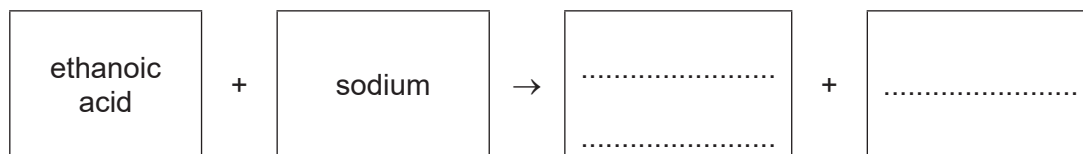
1

2

[2]

(e) Ethanol can be oxidised to ethanoic acid.

Complete the word equation for the reaction of ethanoic acid with sodium.



[2]

[Total: 13]

8 This question is about non-metals.

(a) Non-metals are poor thermal conductors.

Describe two **other** physical properties which are typical of non-metals.

1

2

[2]

(b) Carbon dioxide contributes to increased global warming which leads to climate change.

State **two** strategies which help to reduce climate change caused by carbon dioxide.

1

2

[2]

(c) Water is a simple molecular compound.

(i) Complete Fig. 8.1 to show the dot-and-cross diagram for a molecule of water.

Show outer shell electrons only.

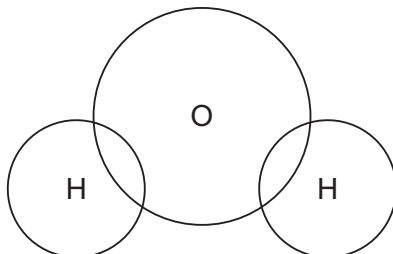


Fig. 8.1

[2]

(ii) State **two** properties of simple molecular compounds.

1

2

[2]

(iii) Water is a good solvent.

State the meaning of the term solvent.

..... [1]

- (iv) Pure water has a neutral pH value.

Choose from the list, the pH value that is neutral.

Draw a circle around your chosen answer.

pH 1 pH 3 pH 7 pH 14 [1]

- (v) A crystal of blue copper(II) sulfate is placed at the bottom of a beaker of water as shown in Fig. 8.2.

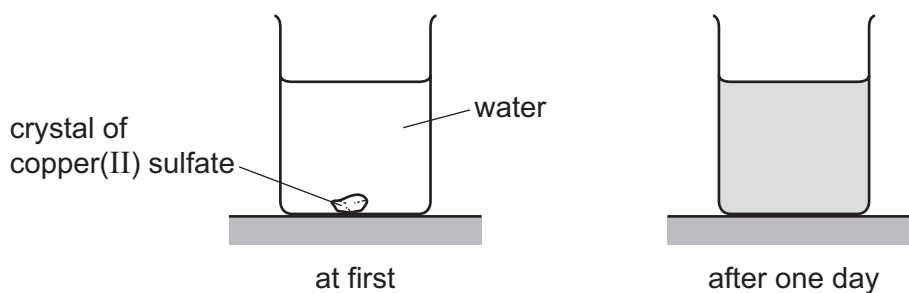


Fig. 8.2

After one day, the blue colour has spread throughout the water in the beaker.

Explain these results in terms of the kinetic particle theory.

.....

.....

.....

..... [3]

[Total: 13]

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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 | Key atomic number atomic symbol name relative atomic mass | | | | | | 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 oganeson — |

lanthanoids

actinoids

| | | | | | | | | | | | | | | |
|------------------------------|----------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-------------------------------|------------------------------|---------------------------|-------------------------------|------------------------------|------------------------------|
| 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 |
| 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 dm³ at room temperature and pressure (r.t.p.).