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**CHEMISTRY****0620/32**

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.





3



(b) Helium is a monatomic gas.

(i) State the meaning of the term monatomic.

..... [1]

(ii) Explain in terms of electronic configuration why helium is unreactive.

.....

..... [1]

[Total: 8]





2 (a) Hydrogen chloride has a simple molecular structure.

(i) State **two** physical properties of a compound with a simple molecular structure.

1 .....

2 ..... [2]

(ii) Hydrogen chloride is a molecule with a covalent bond.

Complete this sentence about a covalent bond.

A covalent bond is formed when two atoms share a pair of ..... [1]

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

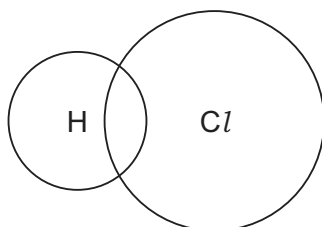


Fig. 2.1

[2]

(b) Zinc chloride has a giant ionic structure of positive and negative ions.

State the general name given to any negative ion.

..... [1]

(c) Diamond is used for jewellery.

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

..... [1]





5



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

Tick (✓) **one** box.

simple covalent molecule

☐

giant covalent

☐

simple ionic

☐

giant ionic

☐

[1]

[Total: 8]





3 (a) The list shows some substances present in water from natural sources.

dissolved oxygen  
calcium compounds  
plastics  
harmful microbes

State which **one** of these substances provides essential minerals for aquatic life.

..... [1]

(b) Explain why phosphates present in polluted water are harmful to aquatic life.

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

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

Table 3.1

| name of ion       | formula of ion      | mass of ion in $1000\text{ cm}^3$ of polluted water / mg |
|-------------------|---------------------|----------------------------------------------------------|
| bromide           | $\text{Br}^-$       | 0.3                                                      |
| calcium           | $\text{Ca}^{2+}$    | 2.5                                                      |
| chloride          | $\text{Cl}^-$       | 3.5                                                      |
| hydrogencarbonate | $\text{HCO}_3^-$    | 10.0                                                     |
| magnesium         | $\text{Mg}^{2+}$    | 0.8                                                      |
| mercury           | $\text{Hg}^{2+}$    | 0.1                                                      |
|                   | $\text{NO}_3^-$     | 0.4                                                      |
| phosphate         | $\text{PO}_4^{3-}$  | 2.0                                                      |
| potassium         | $\text{K}^+$        | 5.9                                                      |
| silicate          | $\text{SiO}_3^{2-}$ | 4.0                                                      |
| sodium            | $\text{Na}^+$       | 12.2                                                     |
| sulfate           | $\text{SO}_4^{2-}$  | 0.5                                                      |

Answer these questions using the information from Table 3.1.

(i) Name the negative ion present in the highest concentration.

..... [1]

(ii) State the name of the  $\text{NO}_3^-$  ion.

..... [1]





(iii) Calculate the mass of phosphate ions present in  $200\text{ cm}^3$  of polluted water.

mass = ..... mg [1]

(d) Fig. 3.1 shows some of the stages in the purification of drinking water.

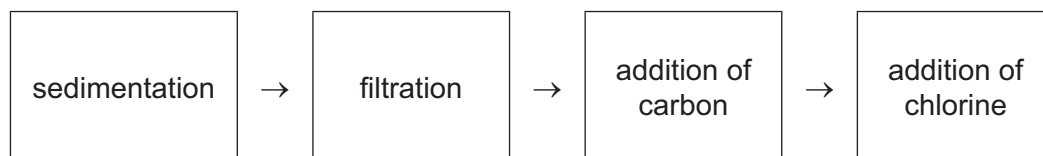


Fig. 3.1

(i) State the purpose of sedimentation.

..... [1]

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

..... [1]

(e) Describe how to test for the purity of water using boiling point.

.....  
 .....  
 .....  
 ..... [2]

(f) Complete the symbol equation for the reaction of disulfur dichloride,  $\text{S}_2\text{Cl}_2$ , with water.



[Total: 11]





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

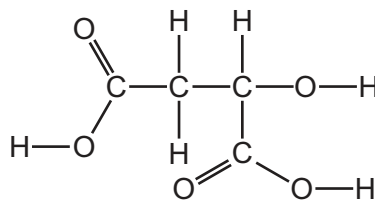


Fig. 4.1

(i) On Fig 4.1 draw a circle around the alcohol 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  $C_8H_{14}O_5$ .

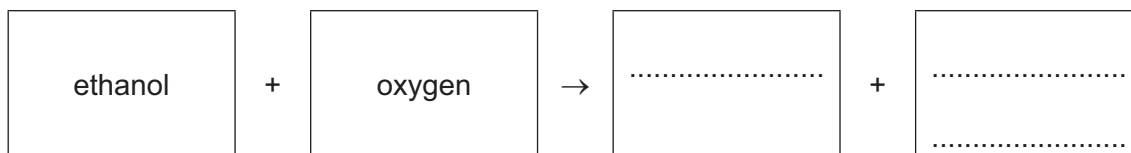
Complete Table 4.1 to calculate the relative molecular mass of  $C_8H_{14}O_5$ .

Table 4.1

| type of atom | number of atoms | relative atomic mass |                    |
|--------------|-----------------|----------------------|--------------------|
| carbon       | 8               | 12                   | $8 \times 12 = 96$ |
| hydrogen     |                 | 1                    |                    |
| oxygen       |                 | 16                   |                    |

relative molecular mass = ..... [2]

(c) Complete the word equation for the complete combustion of ethanol.



[2]





- (d) Table 4.2 shows the names, formulae and boiling points of ethene, propene, butene and pentene.

**Table 4.2**

| name    | formula     | boiling point<br>/°C |
|---------|-------------|----------------------|
| ethene  | $C_2H_4$    | −104                 |
| propene | $C_3H_6$    | −47                  |
| butene  | $C_4H_8$    | −6                   |
| pentene | $C_5H_{10}$ | +30                  |

Use the information in Table 4.2 to answer these questions.

- (i) Name the homologous series that includes ethene, propene, butene and pentene.

..... [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]

- (e) Ethene is manufactured by cracking.

- (i) Describe the manufacture of ethene by cracking.

.....  
.....  
.....  
.....  
..... [3]

- (ii) Give a reason for cracking hydrocarbons.

..... [1]

[Total: 13]





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

Table 5.1

| halogen  | melting point<br>in °C | boiling point<br>in °C | density in liquid<br>state in g/cm <sup>3</sup> |
|----------|------------------------|------------------------|-------------------------------------------------|
| fluorine | −220                   | −188                   |                                                 |
| chlorine | −101                   | −35                    | 1.56                                            |
| bromine  | −7                     | +59                    | 3.12                                            |
| iodine   | +114                   |                        | 3.96                                            |
| astatine | +302                   | +337                   | 6.40                                            |

Use the information in Table 5.1 to predict:

- (i) the boiling point of iodine ..... [1]
- (ii) the density of liquid fluorine ..... [1]
- (iii) the physical state of chlorine at −20 °C. Give a reason for your answer.

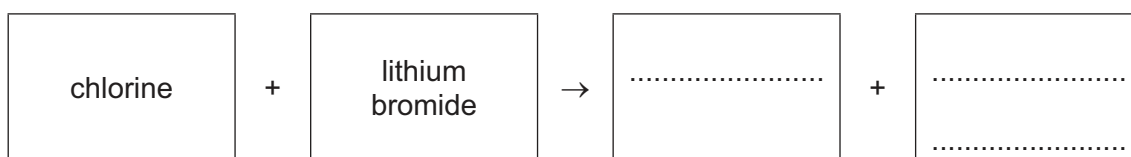
physical state .....

reason .....

..... [2]

(b) Aqueous chlorine reacts with aqueous lithium bromide.

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



[2]

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

..... [1]

- (iii) Describe a test for chlorine.

test .....

observations .....

[2]





11



(c) Fluorine reacts with ammonia to produce hydrogen fluoride and nitrogen.

Complete the symbol equation for this reaction.



[2]

[Total: 11]





6 This question is about metals.

(a) Many metals have high melting points and boiling points.

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 sodium atom and silver ion shown.

Table 6.1

|                          | number of<br>electrons | number of<br>neutrons | number of<br>protons |
|--------------------------|------------------------|-----------------------|----------------------|
| $^{23}_{11}\text{Na}$    | 11                     |                       |                      |
| $^{109}_{47}\text{Ag}^+$ |                        | 62                    |                      |

[3]

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

..... [1]

(c) Silver is a transition element. Sodium is in Group I of the Periodic Table.

State **one** difference in the physical properties of silver and sodium.

..... [1]



(d) Table 6.2 shows the observations when four different metals are heated in oxygen.

Table 6.2

| metal     | observations when heated in oxygen                 |
|-----------|----------------------------------------------------|
| cerium    | burns rapidly and forms an oxide                   |
| copper    | forms an oxide layer very slowly and does not burn |
| lanthanum | forms an oxide layer rapidly and does not burn     |
| silver    | does not form an oxide layer and does not burn     |

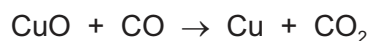
Put the four metals in order of their reactivity.  
Put the least reactive metal first.

least reactive  $\longrightarrow$  most reactive

|  |  |  |  |
|--|--|--|--|
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[2]

(e) Copper(II) oxide is reduced by carbon monoxide.



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

..... [1]

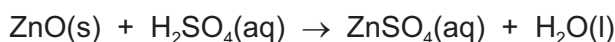
[Total: 11]





7 This question is about acids, bases and salts.

(a) Crystals of zinc sulfate are made by warming excess solid zinc oxide with dilute sulfuric acid.



(i) State the meaning of the state symbol (aq).

..... [1]

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

..... [1]

(b) Crystals of sodium nitrate can be made by neutralising an acid with an alkali.

(i) Name the acid and the alkali used.

acid .....

alkali ..... [2]

(ii) Complete the equation for all neutralisation reactions.



(iii) Neutralisation reactions are exothermic.

Define the term exothermic.

..... [1]

(iv) Fig. 7.1 shows the reaction pathway diagram for an exothermic reaction.

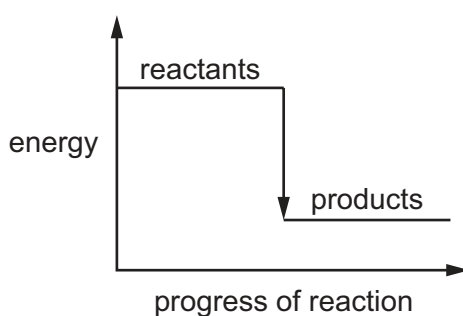


Fig. 7.1

Explain how Fig. 7.1 shows that the reaction is exothermic.

..... [1]





15



(c) Methyl orange is an acid–base indicator.

State the colour of methyl orange 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 calcium carbonate with excess dilute hydrochloric acid of three different concentrations.  
The time taken for each reaction to finish is recorded.

The three concentrations of acid are:

- $0.5 \text{ mol/dm}^3$
- $1.0 \text{ mol/dm}^3$
- $2.0 \text{ mol/dm}^3$ .

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 $\text{mol/dm}^3$ | time taken for the reaction to finish in s |
|----------------------------------------------------------------|--------------------------------------------|
|                                                                | 32                                         |
|                                                                | 64                                         |
|                                                                | 16                                         |

- (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 powdered calcium carbonate is used instead of small pieces of calcium carbonate.  
All other conditions stay the same.  
..... [1]







(b) Molten calcium 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) Choose from the list the substance that is used as an inert electrode.

Draw a circle around your chosen answer.

graphite

iodine

magnesium

phosphorus

[1]

(c) Carbon dioxide is a gas at room temperature.

Describe the motion and separation of the particles in carbon dioxide gas.

motion .....

.....

separation .....

.....

[2]

[Total: 8]





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The Periodic Table of Elements

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

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

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

