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CHEMISTRY

0620/33

Paper 3 Theory (Core)

October/November 2021

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) A list of formulae is shown.

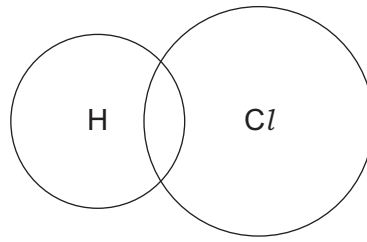
Br₂
 CO
 CO₂
 CH₄
 C₂H₆
 HCl
 KBr
 LiCl
 MgCl₂
 O₂
 SO₂

Answer the following questions using these formulae.
 Each formula may be used once, more than once or not at all.

State which formula represents:

- (i) a compound that gives a red colour in a flame test
 [1]
- (ii) a compound containing an ion with a 2+ charge
 [1]
- (iii) a compound that is a product of respiration
 [1]
- (iv) a compound used as a food preservative
 [1]
- (v) an element that is used in the production of steel.
 [1]

- (b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of hydrogen chloride. Show outer shell electrons only.



[2]

- (c) State whether carbon dioxide is a basic oxide or an acidic oxide.
Give a reason for your answer.

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

[Total: 8]

2 The table shows the masses of some of the ions in 1000 cm³ of water from a river.

| name of ion | formula of ion | mass of ion in 1000 cm ³ of river water / mg |
|-------------|--------------------------------|---|
| ammonium | NH ₄ ⁺ | 1.0 |
| | Ca ²⁺ | 16.5 |
| chloride | Cl ⁻ | 7.0 |
| iron(III) | Fe ³⁺ | 0.5 |
| magnesium | Mg ²⁺ | 4.0 |
| | NO ₃ ⁻ | 0.5 |
| potassium | K ⁺ | 3.5 |
| silicate | SiO ₃ ²⁻ | 7.5 |
| sodium | Na ⁺ | 6.0 |
| sulfate | SO ₄ ²⁻ | 11.0 |

(a) Answer these questions using only the information in the table.

(i) State which positive ion has the lowest concentration.

..... [1]

(ii) Name the compound containing Ca²⁺ and NO₃⁻ ions.

..... [1]

(iii) Calculate the mass of sulfate ions in 500 cm³ of river water.

mass = mg [1]

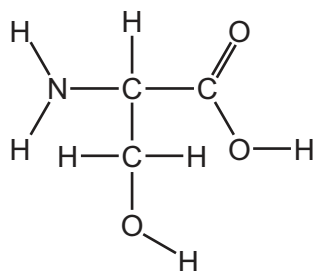
(b) Describe a test for iron(III) ions.

test

observations

[2]

- (c) Compound **A** is found in river water.
The structure of compound **A** is shown.



- (i) On the structure draw a circle around the alcohol functional group. [1]
- (ii) Deduce the formula of compound **A** to show the number of carbon, hydrogen, oxygen and nitrogen atoms.
..... [1]
- (iii) Another compound found in river water has the formula $C_4H_8O_2$.

Complete the table to calculate the relative molecular mass of this compound.

| type of atom | number of atoms | relative atomic mass | |
|--------------|-----------------|----------------------|--------------------|
| carbon | 4 | 12 | $4 \times 12 = 48$ |
| hydrogen | | 1 | |
| oxygen | | 16 | |

relative molecular mass = [2]

[Total: 9]

3 Iron is extracted in a blast furnace using a mixture of iron ore, coke (carbon), air and calcium carbonate (limestone).

(a) Give **two** reasons why air is blown into the blast furnace.

1

2 [2]

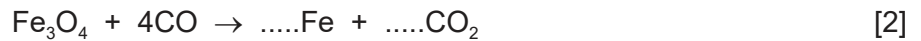
(b) Magnetite is an ore of iron which contains a compound of iron with the formula Fe_3O_4 .

(i) Give the name of another ore of iron.

..... [1]

(ii) In the blast furnace Fe_3O_4 is reduced to Fe.

Complete the chemical equation for the reduction of Fe_3O_4 .



(iii) Explain how this equation shows that Fe_3O_4 is reduced.

..... [1]

(c) Calcium carbonate (limestone) is added to the blast furnace.
The calcium carbonate undergoes thermal decomposition.

Give the meaning of the term *thermal decomposition*.

..... [2]

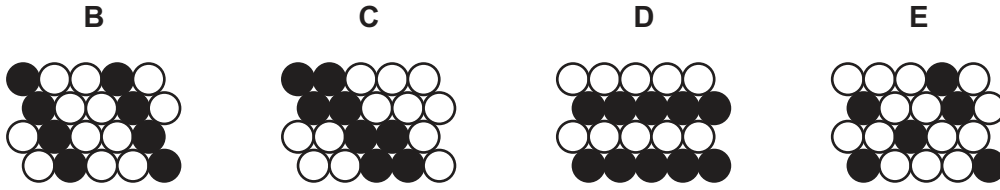
(d) Iron can form alloys such as vanadium steel.

(i) State the meaning of the term *alloy*.

.....

..... [1]

- (ii) Choose from the diagrams, **B**, **C**, **D** or **E**, the structure which best represents an alloy.



structure [1]

- (iii) The symbol for an isotope of vanadium is shown.



Deduce the number of electrons, neutrons and protons in one atom of this isotope of vanadium.

number of electrons

number of neutrons

number of protons

[3]

- (iv) Vanadium is malleable and conducts electricity.

Give two **other** physical properties of vanadium that are characteristic of **all** metals.

1

2

[2]

[Total: 15]

4 The table shows some properties of four halogens in Group VII.

| halogen | melting point /°C | boiling point /°C | density of liquid at boiling point in g/cm ³ |
|----------|-------------------|-------------------|---|
| chlorine | -101 | -35 | 1.56 |
| bromine | -7 | 59 | |
| iodine | 114 | | 4.93 |
| astatine | 302 | 337 | 6.35 |

(a) (i) Complete the table by predicting:

- the boiling point of iodine
- the density of bromine.

[2]

(ii) Describe the trend in the melting points of the halogens down Group VII.

..... [1]

(b) (i) Deduce the electronic structure of chlorine.
Use the Periodic Table to help you.

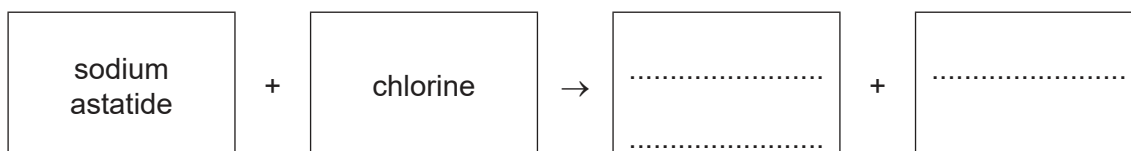
..... [1]

(ii) Explain why a bromide ion has a single negative charge.

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

(c) Scientists have predicted that sodium astatide reacts with chlorine.

Complete the word equation for this reaction.



[2]

- (d) Hydrogen chloride is produced when chlorine reacts with ammonia.
An aqueous solution of hydrogen chloride is acidic.

Describe how you could determine the pH of an acidic solution without using a pH meter.

.....

.....

..... [2]

[Total: 9]

5 The table shows the structures of some organic compounds.

| compound | structure of compound | homologous series |
|----------|---|-------------------|
| F | $ \begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $ | carboxylic acid |
| G | $ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{C}=\text{C} \\ \quad \\ \text{H} \quad \text{H} \end{array} $ | |
| H | $ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $ | |

- (a) Complete the table by naming the homologous series.
The first one has been done for you.

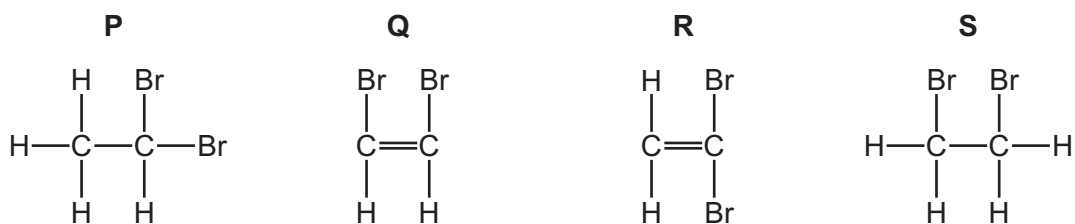
[2]

- (b) Draw the structure of a compound containing two carbon atoms which belongs to the same homologous series as compound **F**.
Show all of the atoms and all of the bonds.

[1]

(c) Compound **G** reacts with bromine.

Choose from the structures, **P**, **Q**, **R** or **S**, the structure of the product formed.



..... [1]

(d) (i) Compound **G** can be obtained by cracking petroleum fractions.

Describe what is meant by the term *cracking*.

.....

..... [2]

(ii) Name the product of the reaction when compound **G** reacts with steam.

..... [1]

(iii) Many molecules of compound **G** can join together to form a compound with a very long chain.

Choose from the list the general name given to a compound that is formed by the addition of many small units.

Draw a circle around the correct answer.

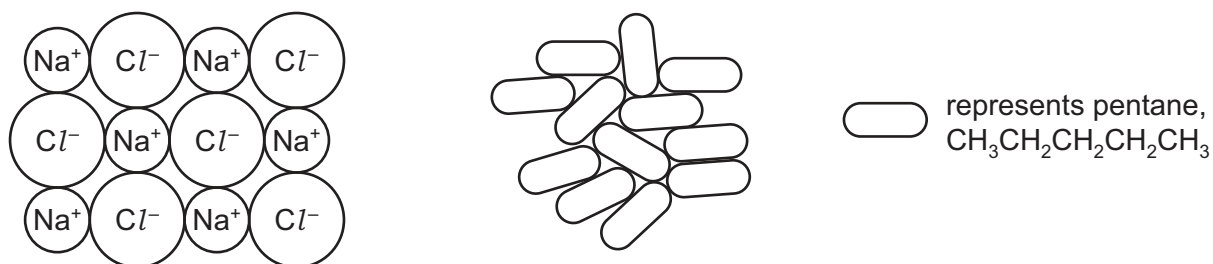
isomer monomer naphtha polymer [1]

(e) State the names of the **two** compounds formed during the complete combustion of compound **H**.

..... and [2]

[Total: 10]

- 6 The diagram shows part of the structures of sodium chloride and pentane at room temperature and pressure.



- (a) Describe the differences in the physical properties of these substances in terms of:

- volatility

sodium chloride

pentane

- solubility in water

sodium chloride

pentane

- electrical conductivity when molten (liquid).

sodium chloride

pentane

[5]

- (b) Concentrated aqueous sodium chloride is electrolysed using carbon (graphite) electrodes.

Name the gas produced at the positive electrode.

..... [1]

- (c) Pentane is a fuel. Under some conditions pentane forms carbon monoxide.

- (i) State the condition under which pentane forms carbon monoxide.

..... [1]

- (ii) State **one** adverse effect of carbon monoxide on health.

..... [1]

[Total: 8]

7 This question is about aluminium and the extraction of metals.

(a) When aluminium is heated above 660 °C it changes from solid to liquid.

(i) Name the change of state from solid to liquid.

..... [1]

(ii) Use the kinetic particle theory to describe the differences between solid aluminium and liquid aluminium in terms of:

- the separation of the particles

.....
.....
.....

- the motion of the particles.

.....
.....
.....

[4]

(b) Aluminium is extracted from aluminium ore by electrolysis.

Explain why aluminium is extracted by electrolysis and **not** by reduction with carbon.

..... [1]

(c) Give **two** reasons why aluminium is used in the manufacture of aircraft.

1

2

[2]

(d) Give **one** advantage of recycling aluminium.

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

(e) The table compares the ease of reduction of four metal oxides when heated with carbon.

| metal oxide | ease of reduction |
|--------------------|------------------------|
| aluminium oxide | not reduced at 2080 °C |
| nickel(II) oxide | reduced at 540 °C |
| titanium(IV) oxide | reduced at 1600 °C |
| zinc oxide | reduced at 850 °C |

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

least reactive $\xrightarrow{\hspace{15em}}$ most reactive

[2]

(f) Methane is used as a fuel in the extraction of some metals.

(i) State the main source of methane.

..... [1]

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

..... [1]

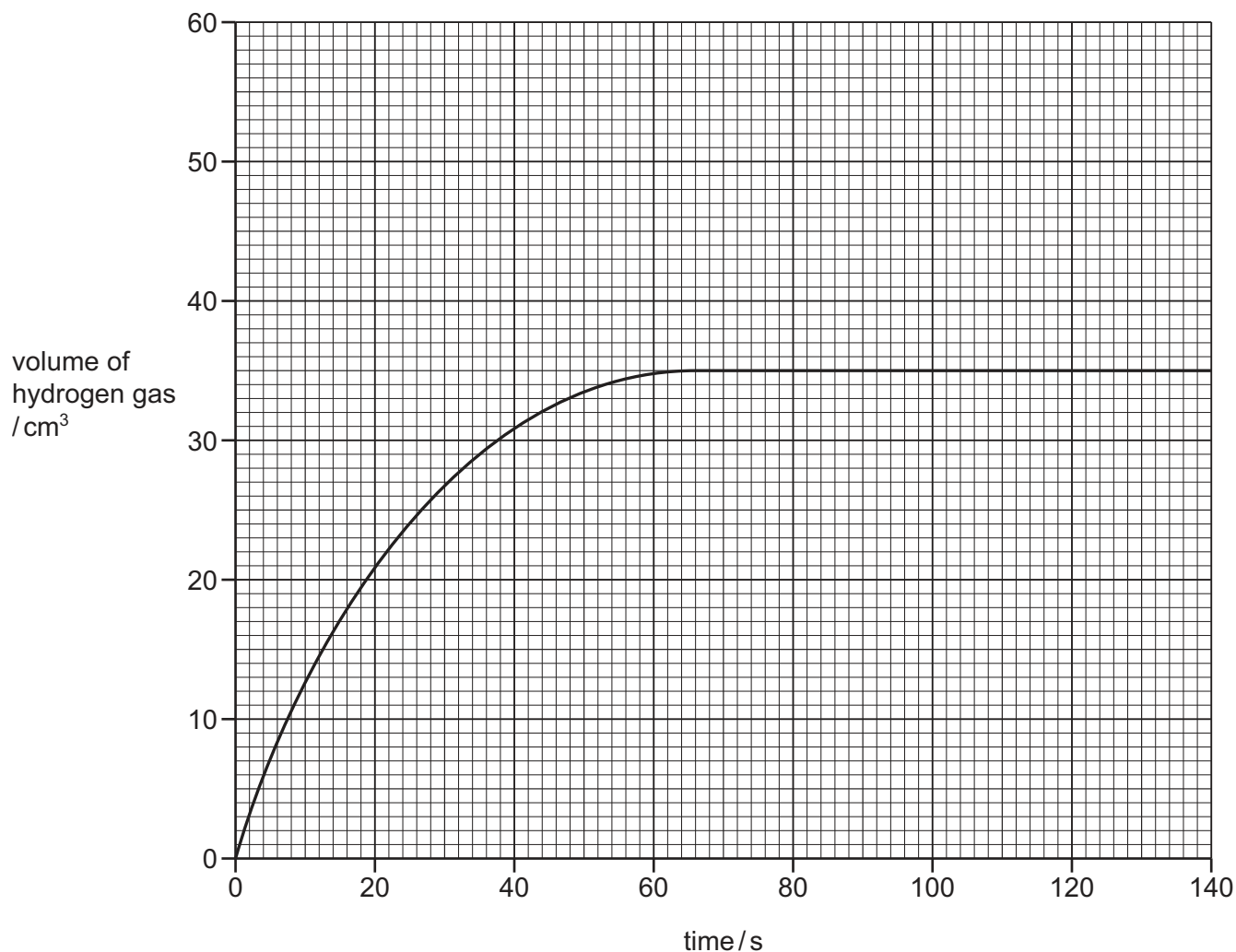
[Total: 13]

- 8 A student investigated the reaction of small pieces of zinc with dilute hydrochloric acid. The hydrochloric acid was in excess.



The rate of reaction is found by measuring the increase in volume of hydrogen gas with time.

The results are shown on the graph.



- (a) Deduce the time taken from the beginning of the experiment to collect 30 cm³ of hydrogen gas.

time = s [1]

- (b) The experiment was repeated using dilute hydrochloric acid of a higher concentration.

All other conditions stayed the same.

Draw a line **on the grid** to show how the volume of hydrogen gas changes with time. [2]

- (c) Describe the effect each of the following has on the rate of reaction of zinc with dilute hydrochloric acid.

All other conditions stay the same.

- The reaction is carried out at a lower temperature.

.....

- The reaction is carried out using zinc powder instead of small pieces of zinc.

.....

[2]

- (d) When 0.065 g of zinc is used, 24 cm³ of hydrogen gas is formed.

Calculate the mass of zinc needed to produce 96 cm³ of hydrogen gas.

mass of zinc = g [1]

- (e) Aqueous ammonia is added to aqueous zinc chloride.

Describe the observations when a few drops of aqueous ammonia are added and when excess aqueous ammonia is added.

a few drops of aqueous ammonia

excess aqueous ammonia

[2]

[Total: 8]

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The Periodic Table of Elements

| | | Group | | | | | | | | | | | | | | | | | | | |
|-----------------------------------|------------------------------------|--|--|------------------------------------|-------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|---------------------------------------|--------------------------------------|--------------------------------------|------------------------------------|------------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|----------------------------------|--|--|--|--|
| I | II | III | IV | V | VI | VII | VIII | | | | | | | | | | | | | | |
| 3 Li lithium 7 | 4 Be beryllium 9 | 1 H hydrogen 1 | 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 | Key atomic number atomic symbol name relative atomic mass | | | | | | | | | | | | | | | | | | | |
| 19 K potassium 39 | 20 Ca calcium 40 | | | | | | | | | | | 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 | | | | |
| 37 Rb rubidium 85 | 38 Sr strontium 88 | 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 | | | | |
| 55 Cs caesium 133 | 56 Ba barium 137 | 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 | | | | |
| 87 Fr francium — | 88 Ra radium — | 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 — | | | | |
| | | 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 — | | 114 Fl flerovium — | 116 Lv livermorium — | | | | | | | |

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.).