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CHEMISTRY

0620/32

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.

CaCO₃
 CaO
 Cl₂
 CH₄
 C₂H₅OH
 C₂H₆
 CuSO₄
 H₂
 H₂O
 MgO
 NaCl
 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 is the main constituent of natural gas

..... [1]

(ii) an element that is used in water treatment

..... [1]

(iii) an element that bleaches damp litmus paper

..... [1]

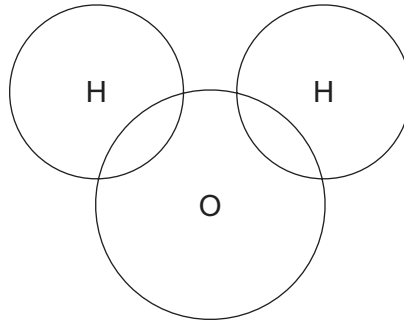
(iv) a compound that contains an ion with a single negative charge

..... [1]

(v) a hydrocarbon that is formed by the decomposition of vegetation.

..... [1]

(b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of water.



[2]

(c) State whether calcium oxide 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 taken from a lake.

| name of ion | formula of ion | mass of ion in 1000 cm ³ of lake water / mg |
|-------------|--------------------------------|--|
| calcium | Ca ²⁺ | 0.41 |
| chloride | Cl ⁻ | 4.40 |
| magnesium | Mg ²⁺ | 0.39 |
| | NO ₃ ⁻ | 0.03 |
| potassium | K ⁺ | 0.30 |
| silicate | SiO ₃ ²⁻ | 0.02 |
| | Na ⁺ | 2.90 |
| sulfate | SO ₄ ²⁻ | 2.80 |

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

(i) State which of the negative ions has the lowest concentration.

..... [1]

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

..... [1]

(iii) Calculate the mass of chloride ions in 250 cm³ of lake water.

mass = mg [1]

(b) Describe a test for sulfate ions.

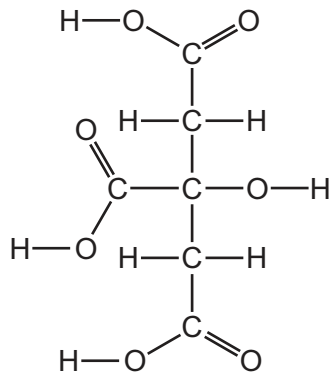
test

observations

[2]

(c) Citric acid is also present in the lake water.

The structure of citric acid is shown.



(i) Deduce the number of carboxylic acid groups in one molecule of citric acid.

..... [1]

(ii) The formula of citric acid is $C_6H_8O_7$.

Complete the table to calculate the relative molecular mass of citric acid.

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

relative molecular mass = [2]

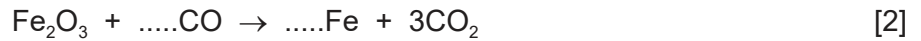
[Total: 8]

3 Iron is extracted from iron ore in a blast furnace.

(a) Name an ore of iron.

..... [1]

(b) (i) Complete the chemical equation for the reduction of iron(III) oxide in the blast furnace.



(ii) State the meaning of the term *reduction*.

..... [1]

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

State the meaning of the term *thermal decomposition*.

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

(d) Iron can be made into stainless steel.

(i) Give **one** use of stainless steel.

..... [1]

(ii) Describe **one** advantage of stainless steel compared with pure iron.

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

(e) The symbol for an isotope of iron is shown.



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

number of electrons

number of neutrons

number of protons

[3]

(f) Iron is a good conductor of heat and electricity.

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

1

2

[2]

(g) Iron rusts.

Name the **two** substances needed for iron to rust.

1

2

[2]

[Total: 15]

4 The table shows some properties of the Group I elements.

| element | melting point /°C | density in g/cm ³ | observations during reaction with water |
|-----------|-------------------|------------------------------|---|
| lithium | 181 | 0.53 | |
| sodium | 98 | | rapid bubbling no flame |
| potassium | | 0.86 | rapid bubbling lilac flame |
| rubidium | 39 | 1.53 | very rapid bubbling red flame |
| caesium | 29 | 1.88 | explodes |
| francium | 27 | | |

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

- the melting point of potassium
- the density of francium.

[2]

(ii) Describe the observations when lithium reacts with water.

.....
 [1]

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

..... [1]

(ii) Explain why a potassium ion has a single positive charge.

.....
 [1]

(c) Sodium reacts with water to produce aqueous sodium hydroxide and a gas which 'pops' with a lighted splint.

(i) Complete the chemical equation for this reaction.



(ii) Choose **one** value from the list that best describes the pH of aqueous sodium hydroxide.

Draw a circle around the correct answer.

pH 1 pH 4 pH 7 pH 14 [1]

[Total: 8]

5 The table shows the structures of some organic compounds.

| compound | structure of compound | homologous series |
|----------|---|-------------------|
| G | $ \begin{array}{ccccc} & \text{H} & & \text{H} & & \text{H} \\ & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & \\ & \text{H} & & \text{H} & & \text{H} \end{array} $ | alkane |
| H | $ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & & & & \\ & & & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{O} & - & \text{H} \\ & & & & & & & & \\ & \text{H} & & \text{H} & & \text{H} & & & \end{array} $ | |
| J | $ \begin{array}{ccccccc} & & & \text{H} & & & & \text{H} \\ & & & & & & & \\ \text{H} & - & \text{C} & - & \text{C} & = & \text{C} \\ & & & & & & \\ & & \text{H} & & \text{H} & & \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 **H**.
Show all of the atoms and all of the bonds.

[1]

(c) Describe the colour change when an excess of compound **J** is added to aqueous bromine.
from to [2]

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

State the conditions needed for cracking.

.....
 [2]

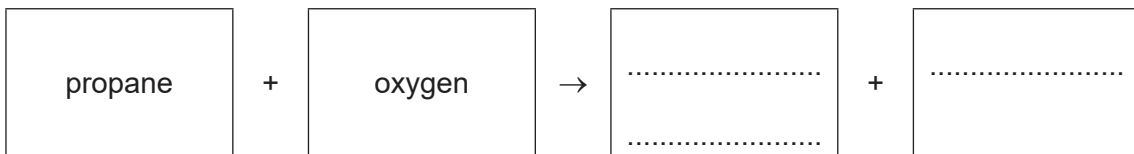
(ii) Complete this sentence about cracking using a word from the list.

bitumen hydrogen oxygen petroleum

The chemicals manufactured by cracking include alkanes, alkenes and [1]

(e) Compound **G** is propane.

Complete the word equation for the complete combustion of propane.



[2]

(f) Compound **J** can form polymers.

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

.....
 [2]

(ii) Nylon is also a polymer.

Give **one** use of nylon.

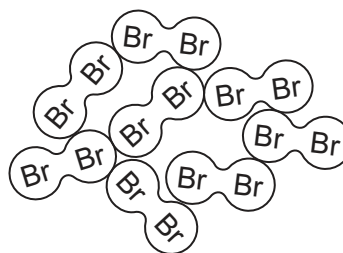
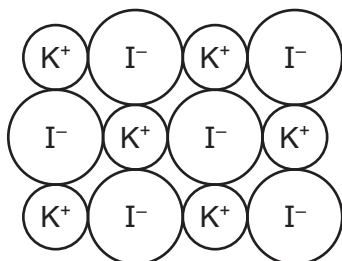
..... [1]

(iii) Describe **one** pollution problem caused by non-biodegradable plastics.

.....
 [1]

[Total: 14]

- 6 The diagrams show part of the structures of potassium iodide and bromine at room temperature and pressure.



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

- volatility

potassium iodide

bromine

- solubility in water

potassium iodide

bromine

- electrical conductivity when molten (liquid).

potassium iodide

bromine

[5]

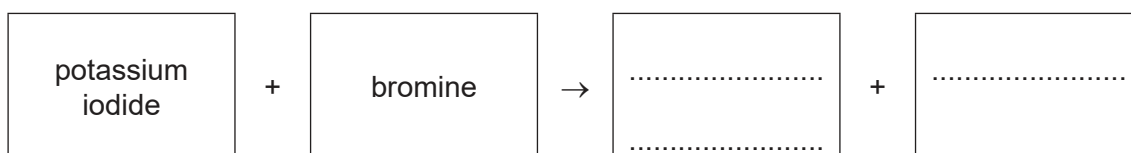
- (b) Molten potassium iodide is electrolysed using carbon (graphite) electrodes.

- (i) Name the substance produced at the positive electrode.

..... [1]

- (ii) Aqueous potassium iodide reacts with aqueous bromine.

Complete the word equation for this reaction.



[2]

(iii) Explain in terms of the reactivity of the halogens why aqueous potassium chloride does **not** react with aqueous bromine.

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

(c) Name the change of state when liquid bromine changes to solid bromine.

..... [1]

[Total: 10]

7 This question is about sulfur and compounds of sulfur.

(a) Use the kinetic particle theory to describe the differences between sulfur gas and solid sulfur in terms of:

- the arrangement of the particles

.....

.....

.....

- the separation of the particles.

.....

.....

.....

[4]

(b) Give the major use of sulfur in industry.

..... [1]

(c) Sulfur dioxide is a pollutant in the air that contributes to acid rain.

(i) State **one** adverse effect of sulfur dioxide on health.

..... [1]

(ii) Name one **other** oxide that contributes to acid rain.

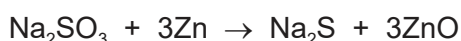
..... [1]

(iii) Sulfur dioxide reacts with water to produce sulfurous acid.
The reaction is reversible.

Draw the symbol for a reversible reaction in the box.



(d) The equation for the reaction of sodium sulfite with zinc is shown.



Explain how this equation shows that zinc is oxidised.

.....

..... [1]

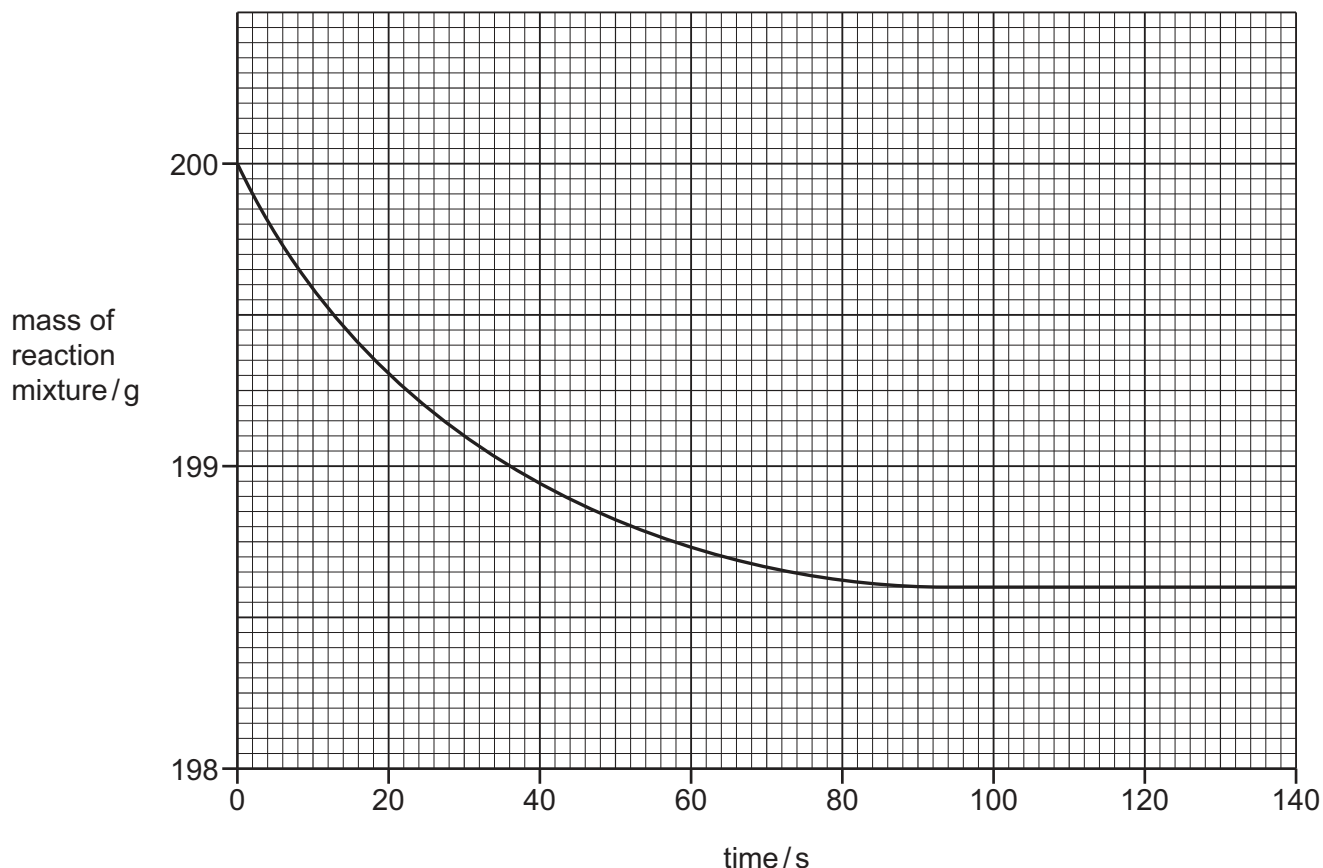
[Total: 9]

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



The rate of reaction is found by measuring the decrease in the mass of the reaction mixture with time.

The results are shown on the graph.



- (a) Deduce the time taken from the beginning of the experiment for the mass of the reaction mixture to decrease by 1.0 g.

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 mass of the reaction mixture changes with time using acid of a higher concentration. [2]

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

All other conditions stay the same.

- The reaction is carried out at a higher temperature.

.....

- The reaction is carried out using large pieces of calcium carbonate instead of small pieces of calcium carbonate.

.....

[2]

- (d) When 0.44 g of calcium carbonate is used, 100 cm³ of carbon dioxide gas is formed.

Calculate the mass of calcium carbonate needed to produce 25 cm³ of carbon dioxide gas.

mass of calcium carbonate = g [1]

- (e) The table compares the reaction of four metals with dilute hydrochloric acid.

| metal | observations |
|-----------|-------------------------------|
| iron | bubbles produced slowly |
| magnesium | bubbles produced very rapidly |
| nickel | bubbles produced very slowly |
| silver | no bubbles produced |

Put the four metals in order of their reactivity.

Put the least reactive metal first.

least reactive \longrightarrow most reactive

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

[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 | 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 — | 114 Fl flerovium — | 116 Lv livermorium — | — | — | — | — |

lanthanoids

| | | | | | | | | | | | | | | |
|------------------------------|----------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-------------------------------|------------------------------|---------------------------|-------------------------------|------------------------------|------------------------------|
| 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 — |

actinoids

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