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CHEMISTRY

0620/31

Paper 3 Theory (Core)

May/June 2017

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

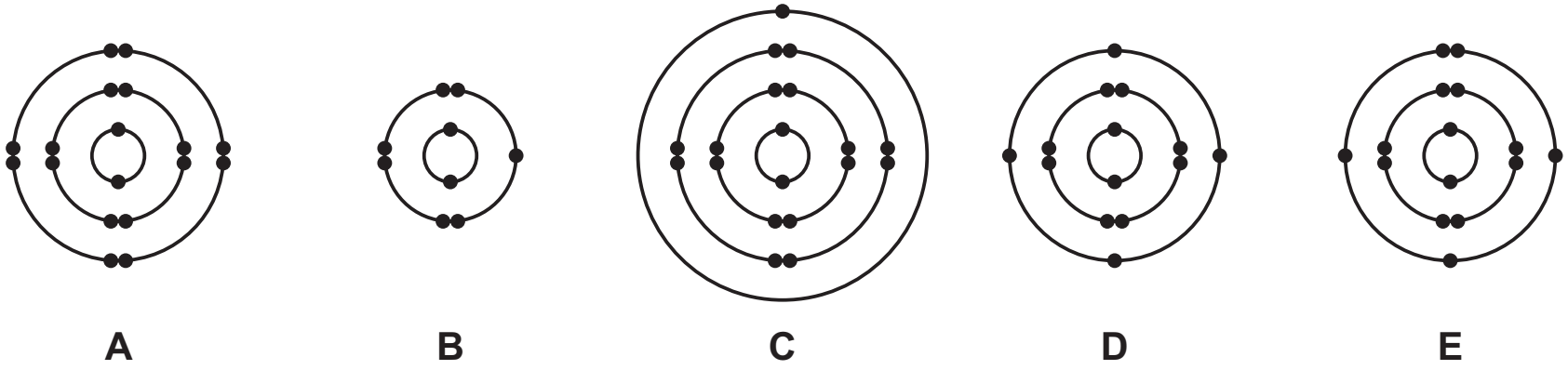
A copy of the Periodic Table is printed on page 16.

You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

1 (a) The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.



Answer the following questions about these atoms.
Each atom may be used once, more than once or not at all.

Which atom, **A**, **B**, **C**, **D** or **E**,

- (i) has a complete outer shell of electrons, [1]
- (ii) has a proton number of 15, [1]
- (iii) has 4 shells containing electrons, [1]
- (iv) is a fluorine atom, [1]
- (v) is an atom of a metallic element? [1]

(b) Complete the table to show the number of electrons, neutrons and protons in the chlorine atom and bromide ion shown.

| | number of electrons | number of neutrons | number of protons |
|-----------------------------|---------------------|--------------------|-------------------|
| ${}_{17}^{35}\text{Cl}$ | 17 | | |
| ${}_{35}^{79}\text{Br}^{-}$ | | 44 | |

[3]

[Total: 8]

2 (a) The table shows the ions present in a 1000 cm³ sample of polluted river water.

| ion present | formula of ion | mass present in mg/ 1000 cm ³ |
|-------------------|--------------------------------|--|
| calcium | Ca ²⁺ | 2.0 |
| chloride | Cl ⁻ | 1.3 |
| hydrogencarbonate | HCO ₃ ⁻ | 2.0 |
| magnesium | Mg ²⁺ | 1.0 |
| potassium | K ⁺ | 4.0 |
| silicate | SiO ₃ ²⁻ | 12.0 |
| sodium | Na ⁺ | 11.0 |
| | SO ₃ ²⁻ | 3.0 |

Answer these questions using the information from the table.

(i) Which positive ion is present in the highest concentration?

..... [1]

(ii) State the name of the ion SO₃²⁻.

..... [1]

(iii) Calculate the mass of silicate ions present in 250 cm³ of this sample.

mass of silicate ions = mg [1]

(iv) Calculate the mass of solid formed when all the water is evaporated from the 1000 cm³ sample.

mass of solid formed = mg [1]

(v) Name the compound containing Ca²⁺ ions and HCO₃⁻ ions.

..... [1]

(b) Describe a test for sodium ions.

test

result

[2]

(c) The formulae of some chlorides are given.

aluminium chloride, $AlCl_3$

calcium chloride, $CaCl_2$

sodium chloride, $NaCl$

Deduce the formula for magnesium chloride.

..... [1]

(d) Molten calcium chloride can be electrolysed using inert electrodes.

Predict the products of this electrolysis at

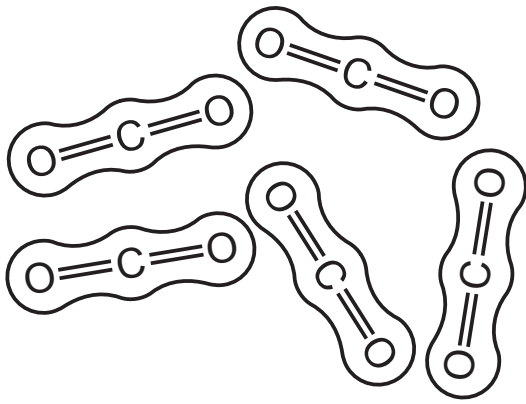
the negative electrode (cathode),

the positive electrode (anode).

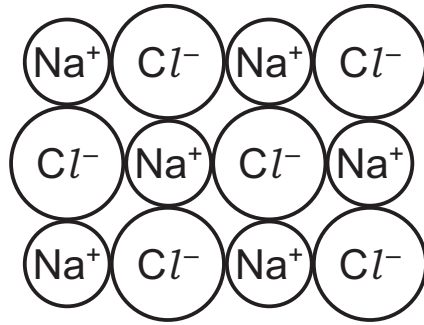
[2]

[Total: 10]

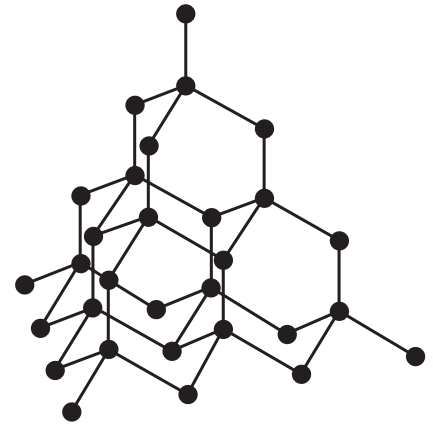
3 The diagram shows part of the structures of three substances, **X**, **Y** and **Z**, at room temperature and pressure.



X



Y



Z

(a) Describe substances **X**, **Y** and **Z** in terms of

- their bonding,
- the arrangement of their particles,
- the motion of their particles.

.....

.....

.....

.....

.....

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.....

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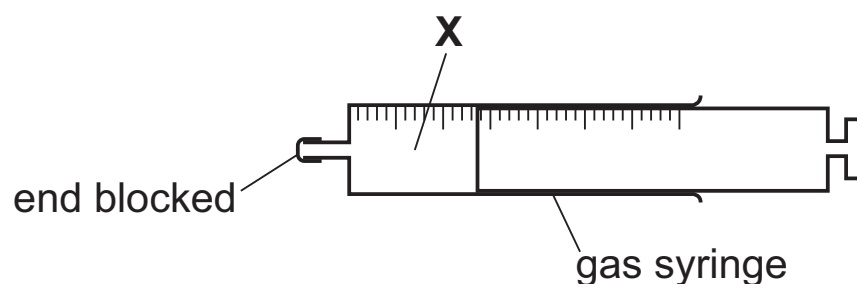
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.....

.....

..... [5]

(b) A closed gas syringe contains substance **X**.



Describe what happens to the volume of substance **X** in the syringe when the pressure is increased. The temperature remains constant. Explain your answer in terms of particles.

.....
 [2]

(c) Substance **Z** is diamond. Diamond is used in jewellery.

Give **one** other use of diamond.

..... [1]

(d) Substance **Y** undergoes physical and chemical changes.

Which **two** of the following are physical changes? Explain your answer.

- A** Substance **Y** dissolves easily in water.
- B** An aqueous solution of substance **Y** gives a white precipitate with acidified aqueous silver nitrate.
- C** Substance **Y** melts at 801 °C.
- D** Substance **Y** reacts with concentrated sulfuric acid.

.....

 [3]

[Total: 11]

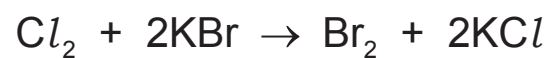
4 Chlorine is an element in Group VII of the Periodic Table.

(a) Chlorine is a diatomic molecule.

Explain what is meant by the term *diatomic*.

..... [1]

(b) Aqueous chlorine reacts with aqueous potassium bromide.



(i) How does this equation show that chlorine is more reactive than bromine?

..... [1]

(ii) Aqueous potassium bromide and aqueous potassium chloride are both colourless.

Predict the colour change when aqueous chlorine reacts with aqueous potassium bromide.

..... [1]

(iii) Complete the chemical equation for the reaction of aqueous bromine with aqueous potassium iodide.



[2]

(c) Describe a test for iodide ions.

test

result

[2]

(d) Chlorine is used to make the polymer PVC.

(i) Give **one** other use of chlorine.

..... [1]

(ii) The monomer used to make PVC is made by the thermal decomposition of dichloroethane.



Explain what is meant by the term *thermal decomposition*.

.....
 [2]

(iii) PVC is a non-biodegradable plastic.

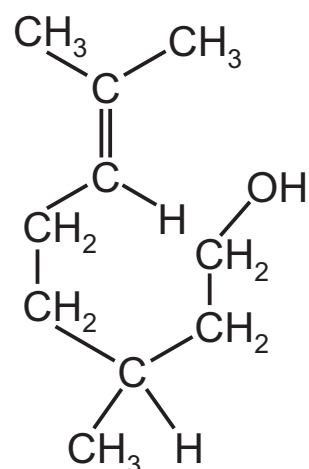
Describe **two** pollution problems caused by non-biodegradable plastics.

1
 2 [2]

[Total: 12]

5 Citronellol is found in rose oil.

The structure of citronellol is shown.



(a) On the structure shown draw a circle around the alcohol functional group. [1]

(b) How many hydrogen atoms are there in **one** molecule of citronellol?

..... [1]

(c) What feature of the citronellol structure shows that it is unsaturated?

..... [1]

(d) The table shows the properties of some alkanes.

| alkane | number of carbon atoms in one molecule | melting point in °C | boiling point in °C | density of liquid alkane in g/cm ³ |
|---------|--|---------------------|---------------------|---|
| methane | 1 | -182 | -162 | 0.466 |
| ethane | 2 | -183 | -88 | 0.572 |
| propane | 3 | -188 | | 0.585 |
| butane | 4 | | 0 | 0.601 |
| pentane | 5 | -130 | 36 | 0.626 |

(i) Describe how the density of the liquid alkanes varies with the number of carbon atoms in one molecule.

..... [1]

(ii) Predict the boiling point of propane.

..... [1]

(iii) Why would it be difficult to predict the melting point of butane from the information in the table?

..... [1]

(iv) What is the state of pentane at 30 °C? Explain your answer.

..... [2]

(v) Alkanes are hydrocarbons.

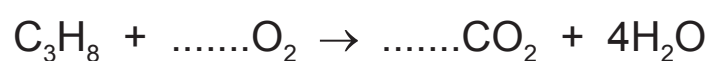
What is the meaning of the term *hydrocarbon*?

..... [2]

(vi) Draw the structure of ethane. Show all of the atoms and all of the bonds.

[1]

(vii) Complete the chemical equation for the combustion of propane.



[2]

[Total: 13]

6 (a) The table shows the properties of some metals.

| metal | density in g/cm ³ | melting point in °C | relative strength | relative electrical conductivity | cost |
|-----------|---------------------------------|------------------------|----------------------|--|----------------|
| aluminium | 2.7 | 660 | 7.0 | 4.0 | expensive |
| iron | 7.9 | 1535 | 21.0 | 1.1 | cheap |
| lead | 11.3 | 328 | 1.5 | 0.5 | expensive |
| silver | 10.5 | 962 | 2.0 | 6.7 | very expensive |
| tungsten | 19.4 | 3420 | 12.0 | 2.0 | expensive |

Use the information in the table to answer the questions.

(i) Which metal would be most useful for making overhead power cables?
Give **two** reasons for your answer.

metal

reason 1

reason 2 [2]

(ii) Why is iron and **not** tungsten used to reinforce concrete?

..... [1]

(iii) The front part of a space rocket is called a nose cone. The nose cone gets **very** hot as the space rocket moves through the air.

Which metal is best to make a space rocket nose cone? Explain your answer.

..... [1]

(b) Tungsten is a transition element.

State **two** physical properties of transition elements which are **not** shown by Group I elements.

1

2 [2]

(c) When extremely hot tungsten reacts with oxygen, tungsten(VI) oxide is formed.

Balance the chemical equation for this reaction.



[2]

(d) Some information about the reaction of four metals with oxygen is given.

cobalt: reacts slowly at high temperatures

iron: thin wire burns when heated strongly

magnesium: burns when heated

tungsten: reacts very slowly at extremely high temperatures

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

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

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

[2]

(e) The table compares the time taken for reaction of an alloy with ethanoic acid, nitric acid and phosphoric acid, each at three different concentrations. The time taken for the alloy to decrease in mass by 1.0 g was measured. All other conditions were kept the same.

| acid | time taken for reaction/hours | | |
|-----------------|---|---|---|
| | concentration of acid 0.04 mol/dm ³ | concentration of acid 0.02 mol/dm ³ | concentration of acid 0.01 mol/dm ³ |
| ethanoic acid | 92 | 190 | 410 |
| nitric acid | 2 | 6 | 18 |
| phosphoric acid | 19 | 39 | 80 |

(i) How does the concentration of acid affect the rate of reaction?

.....
 [1]

(ii) Which acid reacts most rapidly with the alloy?

..... [1]

- (iii) Predict how long it would take for the alloy to decrease in mass by 1.0 g using phosphoric acid of concentration 0.03 mol/dm^3 .

time taken = hours [1]

- (iv) Suggest which **one** of these pH values is the pH of concentrated aqueous ethanoic acid. Draw a circle around the correct answer.

pH 4

pH 7

pH 10

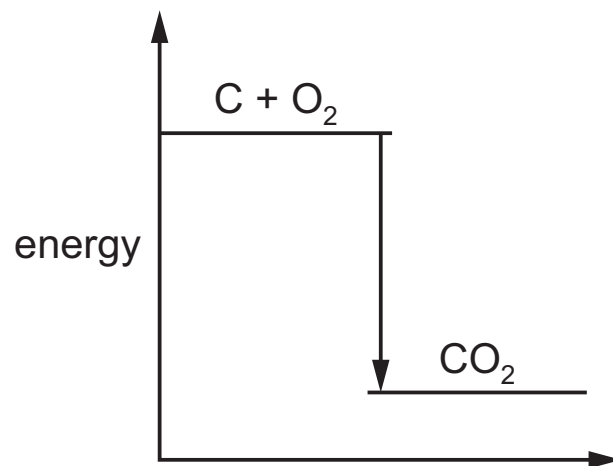
pH 13

[1]

[Total: 14]

7 Carbon is an element in Group IV of the Periodic Table. It reacts with oxygen to form carbon dioxide.

(a) The energy level diagram for this reaction is shown.



Explain how this diagram shows that the reaction is exothermic.

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

(b) Carbon monoxide, carbon dioxide and methane are all atmospheric pollutants.

- Give the sources of these gases.
- Describe the effects that both carbon dioxide and methane have on the environment.
- State an adverse effect of carbon monoxide on health.

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
..... [5]

(c) Calcium carbonate decomposes to form calcium oxide (lime) and carbon dioxide.

(i) State **one** use of calcium oxide.

..... [1]

(ii) Calculate the relative formula mass of calcium carbonate, CaCO_3 .

Show all your working.

Use your Periodic Table to help you.

relative formula mass = [2]

(d) Carbon and magnesium are both insoluble in water.

Carbon does **not** react with hydrochloric acid but magnesium reacts to form a soluble salt and a gas which escapes into the air.

Suggest how you could prepare a pure dry sample of carbon from a mixture of carbon powder and magnesium powder.

.....

 [3]

[Total: 12]

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

Key

| |
|----------------------|
| atomic number |
| atomic symbol |
| name |
| relative atomic mass |

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.).