Cambridge Assessment International Education

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CHEMISTRY **0620/31**

Paper 3 Theory (Core) **May/June 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 **16** pages. Any blank pages are indicated.

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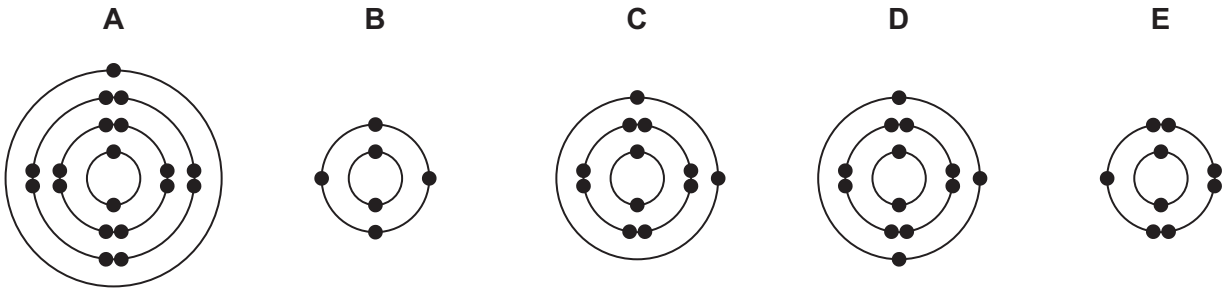
1 **(a)** The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.

View solution



Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom in Group II of the Periodic Table

..... [1]

(ii) an atom with a proton number of 13

View solution

..... [1]

(iii) an atom that forms a stable ion with a single negative charge

View solution

..... [1]

(iv) an atom of a non-metal that forms a giant covalent structure

View solution

..... [1]

(v) an atom of a metal used in food containers.

View solution

..... [1]

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

View solution

	number of electrons	number of neutrons	number of protons
$^{51}_{23}V$	23		
$^{48}_{20}Ca^{2+}$		28	

[3]

[Total: 8]

2 The table shows the masses of some of the ions in 1000 cm^3 of fruit juice.

name of ion	formula of ion	mass of ion in 1000 cm^3 of fruit juice / mg
	NH_4^+	43
calcium	Ca^{2+}	79
chloride	Cl^-	135
lithium	Li^+	1
magnesium	Mg^{2+}	80
nitrate	NO_3^-	35
phosphate	PO_4^{3-}	120
potassium	K^+	575
sodium	Na^+	120
	SO_4^{2-}	105

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

View solution

(i) State which negative ion has the highest mass in 1000 cm^3 of fruit juice.

..... [1]

(ii) Give the formulae of the ions in ammonium sulfate.

View solution

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

(iii) Calculate the mass of sodium ions in 200 cm^3 of fruit juice.

View solution

mass = ... mg [1]

(b) Describe a test for lithium ions.

View solution

test .....

observations .....

[2]

(c) Ions of the element potassium, K, are present in most fertilisers.

View solution

State the names of two **other** elements that are in most fertilisers.

1 .....

2 .....

[2]

(d) Orange juice is acidic.

Draw a circle around the pH of orange juice.

View solution

pH 4 **pH 7** **pH 10** **pH 13** [1]

(e) Some soils are acidic.

View solution

Give the names of **two** compounds that are used to make soils less acidic.

1 .....

2 .....
[2]

(f) Hydrogen chloride is an acidic gas produced when concentrated hydrochloric acid evaporates.

(i) Describe the arrangement and separation of the molecules in hydrogen chloride gas.

View solution

arrangement .....

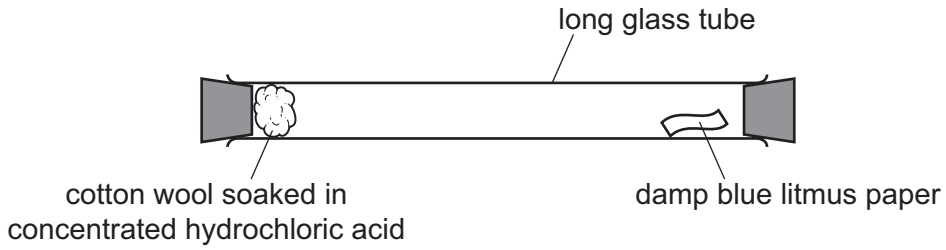
.....

separation .....

.....
[2]

(ii) A long glass tube is set up as shown.

View solution



At first, the blue litmus paper does not turn red.
After a short time, the litmus paper turns red.

Explain these observations using the kinetic particle model.

.....

.....

.....

.....

..... [3]

[Total: 15]

3 The table shows some properties of four Group I elements.

element	melting point / °C	boiling point / °C	atomic radius / nm
sodium	98	883	0.191
potassium	63	760	
rubidium	39		0.250
caesium	29	671	0.272

View solution

(a) (i) Complete the table by predicting:
- the boiling point of rubidium
- the atomic radius of potassium.

[2]

(ii) Describe the trend in the melting point of the Group I elements down the group.

..... [1]

(iii) Deduce the physical state of potassium at 60 °C.
Explain your answer.

.....

.....

..... [2]

View solution

(b) Caesium is a radioactive element with a proton number of 55.

(i) Define proton number.

..... [1]

(ii) State **one** industrial use of radioactive isotopes.

..... [1]

View solution

(c) Sodium hydride, NaH, reacts with iron(III) oxide.

(i) Balance the equation for this reaction.

$$Fe_2O_3 + 3NaH \rightarrow .....Fe + ...NaOH$$ [2]

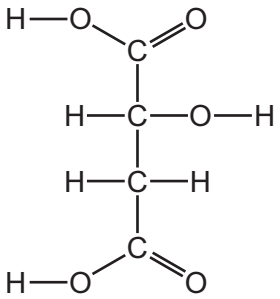
View solution

(ii) Explain how this equation shows that iron(III) oxide is reduced.

..... [1]

[Total: 10]

4 The structure of malic acid is shown.



View solution

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

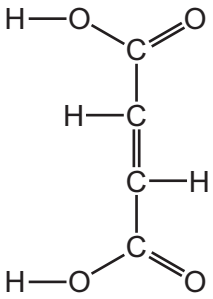
(ii) Deduce the formula of malic acid to show the number of carbon, hydrogen and oxygen atoms.

..... [1]

View solution

(b) When malic acid is heated it forms compound **F**.

The structure of compound **F** is shown.



Explain why compound **F** is described as unsaturated.

..... [1]

View solution

(c) Compound **F** can form polymers.

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

.....

..... [2]

(ii) State the name of the polymer formed when ethene is polymerised.

..... [1]

View solution

(d) Ethanoic acid is a carboxylic acid.

View solution

Describe the observations made when dilute ethanoic acid reacts with:

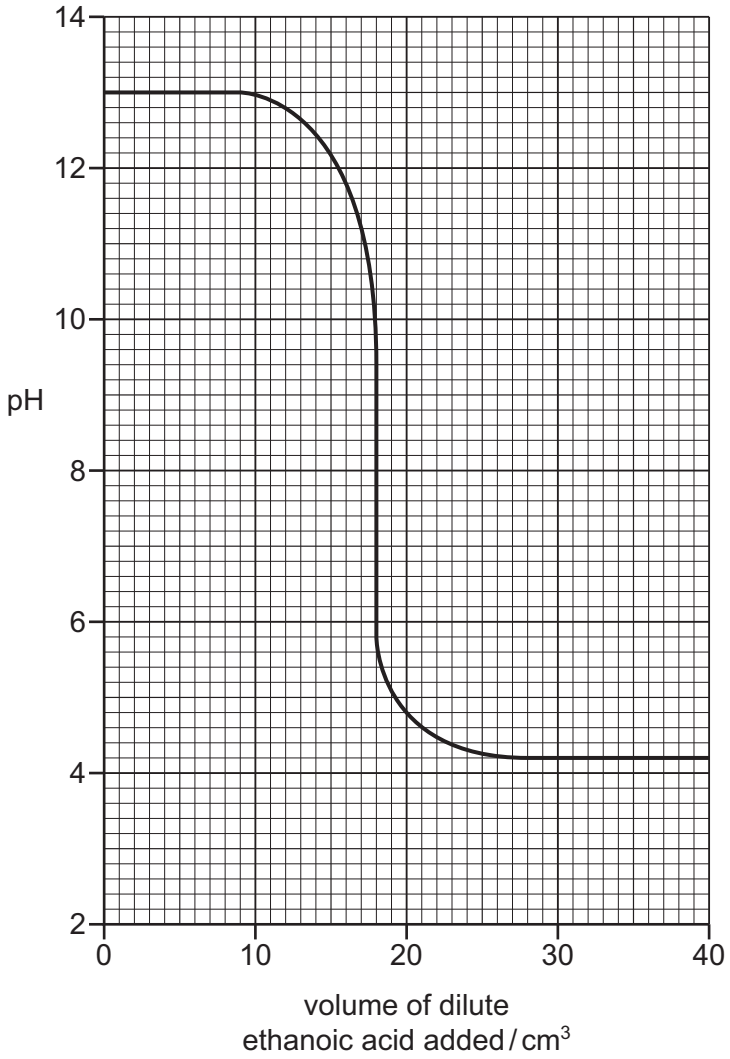
magnesium .....

litmus solution. .....

[2]

(e) The graph shows how the pH changes when dilute ethanoic acid is added slowly to aqueous sodium hydroxide.

View solution



(i) Deduce the pH of the aqueous sodium hydroxide before the addition of dilute ethanoic acid.

pH = ... [1]

(ii) Deduce the volume of dilute ethanoic acid added when the pH is neutral.

..... cm^3 [1]

[Total: 10]

5 **(a)** Calcium oxide is made by the thermal decomposition of calcium carbonate.

View solution

(i) State the meaning of the term *thermal decomposition*.

.....

..... [2]

(ii) Describe a test for calcium ions.

View solution

test .....

observations .....

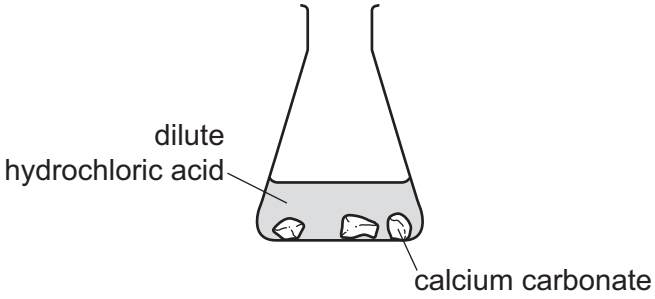
[2]

(b) Carbon dioxide is produced when dilute hydrochloric acid reacts with calcium carbonate.

View solution

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

(i) Complete the diagram to show how to measure the volume of carbon dioxide produced during this reaction.



[2]

(ii) Describe the effect of each of the following on the rate of reaction of dilute hydrochloric acid with calcium carbonate.

View solution

- The concentration of hydrochloric acid is decreased.

All other conditions stay the same.

.....

- The temperature is increased.

All other conditions stay the same.

.....
[2]

View solution

(c) Carbon dioxide is also formed when the hydrocarbon C_3H_8 is completely combusted.

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

.....

..... [2]

View solution

(ii) The hydrocarbon C_3H_8 is called propane.

Name the homologous series that propane belongs to.

..... [1]

(iii) Name two substances formed by the incomplete combustion of propane.

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

[Total: 13]

View solution

6 This question is about water.

(a) The water in rivers often contains pollutants such as acids.

View solution

Describe how universal indicator paper can be used to determine the pH value of the water.

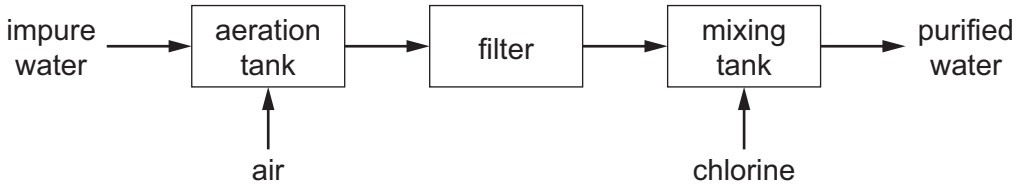
.....

.....

..... [2]

(b) The diagram shows some of the stages in water treatment.

View solution



(i) Air is blown through the aeration tank.

Name the **two** gases that make up most of the air.

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

(ii) After aeration, the water still contains large insoluble particles.

View solution

The filter is made up of fine sand and stones.

Explain how the filter helps purify the water.

.....

.....

..... [2]

(iii) Explain why chlorine is used in water treatment.

View solution

..... [1]

(c) Anhydrous cobalt(II) chloride is used to test for water.

View solution

State the colour change in this test.

from ..... to ..... [2]

[Total: 9]

7 **(a)** Molten lead(II) bromide is electrolysed using carbon electrodes.

View solution

(i) State the products of this electrolysis at:

the negative electrode .....

the positive electrode. .....

[2]

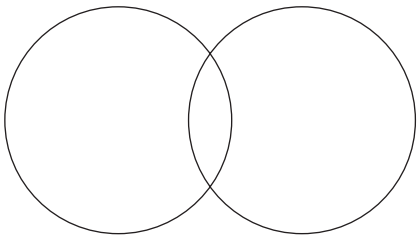
(ii) State the name of **another** substance which can be used as an inert electrode. View solution

..... [1]

(b) When aqueous magnesium chloride is electrolysed using carbon electrodes, hydrogen gas is produced at the negative electrode.

Complete the dot-and-cross diagram to show the electron arrangement in one molecule of hydrogen.

View solution



[1]

[Total: 4]

8 This question is about elements in the Periodic Table.

(a) The table shows some properties of five elements, **P**, **Q**, **R**, **S** and **T**.

View solution

element	melting point / °C	density in g / cm^3	electrical conductivity of the solid	atomic radius / nm
P	1535	7.86	very good	0.125
Q	–7	3.12	does not conduct	0.114
R	1495	8.90	very good	0.126
S	–157	0.0035	does not conduct	0.110
T	839	1.54	very good	0.174

Use only the elements shown in the table to answer this question.

State which two of the elements, **P**, **Q**, **R**, **S** and **T**, are covalent molecules.
Give **two** reasons for your answer.

elements ..... and .....

reason 1 .....

reason 2 .....

[3]

(b) Element **T** is on the left-hand side of the Periodic Table.
Suggest whether its oxide is acidic or basic.

View solution

Give a reason for your answer.

.....

..... [1]

(c) Krypton is an element in Group VIII of the Periodic Table.

View solution

Explain, using ideas about electronic structure, why krypton is unreactive.

.....

..... [1]

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

View solution

Iron has a higher melting point and higher boiling point than sodium.

Give **two** other ways in which the properties of transition elements differ from the properties of Group I elements.

1 .....

2 .....

[2]

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

View solution

metal	reaction with dilute hydrochloric acid
calcium	reacts very rapidly
copper	no reaction
iron	reacts rapidly
nickel	reacts slowly

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

least reactive ⟶ most reactive

[2]

(f) Hot iron reacts with steam. The reaction is reversible.

View solution

Complete the equation by writing the symbol for a reversible reaction in the box.

$$3Fe + 4H_2O \square Fe_3O_4 + 4H_2$$

[1]

(g) Steel is an alloy of iron.

View solution

State the meaning of the term *alloy*.

..... [1]

[Total: 11]

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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											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											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
actinoids	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 dm^3 at room temperature and pressure (r.t.p.).