



## Cambridge IGCSE™ (9–1)

CANDIDATE  
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**CHEMISTRY**

**0971/42**

Paper 4 Theory (Extended)

**October/November 2022**

**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.



## 2

1 Diamond and graphite are different solid forms of carbon. The carbon atoms in diamond and graphite are arranged in different ways.

(a) State the number of covalent bonds each carbon atom has in diamond.

..... [1]

(b) State the term used to describe the structure of diamond.

..... [1]

(c) Name an oxide that has a similar structure to diamond.

..... [1]

(d) Describe the arrangement of atoms in graphite.

.....

..... [2]

(e) Explain how graphite conducts electricity.

..... [1]

(f) Buckminsterfullerene is a simple molecular form of carbon.

The relative molecular mass of Buckminsterfullerene is 720.

Determine the number of carbon atoms in one molecule of Buckminsterfullerene.

..... [1]

(g) All forms of carbon burn to produce carbon dioxide.

Name the substance used to test for carbon dioxide.

..... [1]

[Total: 8]

2 Sodium is a reactive metal.

(a) Suggest why sodium is stored under oil.

..... [1]

(b) Sodium burns in air to form sodium oxide,  $\text{Na}_2\text{O}$ .

(i) State the term given to a reaction in which a substance burns.

..... [1]

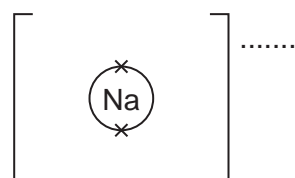
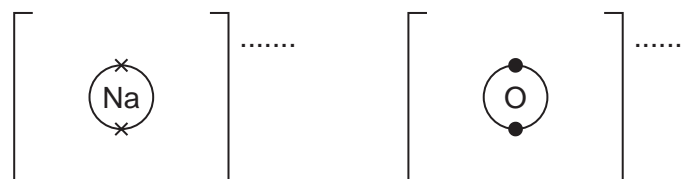
(ii) State the colour of the flame seen when sodium burns.

..... [1]

(iii) Write a chemical equation for the reaction which takes place when sodium burns in air to form sodium oxide.

..... [2]

(iv) Complete the dot-and-cross diagram to show the electron arrangement and charges of the ions in sodium oxide.



[3]

(c) Sodium reacts vigorously with water to form aqueous sodium hydroxide, NaOH, which is a strong base.

(i) Explain in terms of proton transfer what is meant by a base.

..... [1]

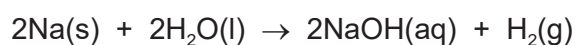
(ii) State a pH number that indicates the presence of a strong alkali.

..... [1]

(iii) State the colour of methyl orange in aqueous sodium hydroxide.

..... [1]

(iv) The equation for the reaction is shown.



Calculate the concentration of NaOH(aq) formed, in g/dm<sup>3</sup>, when 0.345 g of sodium is added to 50.0 cm<sup>3</sup> of distilled water. Assume there is no change in volume.

Use the following steps.

- Calculate the number of moles of Na added.

= ..... mol

- Determine the number of moles of NaOH formed.

= ..... mol

- Calculate the concentration of NaOH in mol/dm<sup>3</sup>.

concentration of NaOH = ..... mol/dm<sup>3</sup>

- Determine the  $M_r$  of NaOH and calculate the concentration of NaOH in g/dm<sup>3</sup>.

concentration of NaOH = ..... g/dm<sup>3</sup>  
[5]

## 5

**(d)** When  $\text{NaOH}(\text{aq})$  is added to aqueous iron(III) chloride,  $\text{FeCl}_3(\text{aq})$ , a solid product is formed.

**(i)** Name the type of reaction where a solid is formed from two solutions.

..... [1]

**(ii)** State the colour of this solid product.

..... [1]

**(iii)** Name this solid product.

..... [1]

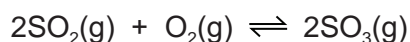
**(iv)** Write the ionic equation for the reaction. Include state symbols.

..... [3]

[Total: 22]

## 6

- 3 Sulfuric acid is manufactured by an industrial process. Sulfur is obtained from sulfur-containing metal ores.  
The sulfur in the metal ore is converted to sulfur dioxide which is then oxidised to sulfur trioxide as shown.



- (a) Name a metal ore which contains sulfur.

..... [1]

- (b) Describe the process which converts metal ores to sulfur dioxide.

..... [1]

- (c) Name the industrial process used to manufacture sulfuric acid.

..... [1]

- (d) The reaction that produces sulfur trioxide is an equilibrium. The forward reaction is exothermic.

- (i) State the temperature and pressure used to make sulfur trioxide.

temperature = ..... °C

pressure = ..... atm  
[2]

- (ii) Name the catalyst used.

..... [1]

- (iii) Describe **two** features of an equilibrium.

1 .....

2 .....

[2]

- (iv) State the effect, if any, on the position of equilibrium when the following changes are made.

Explain your answers.

temperature is increased .....

.....

pressure is increased .....

.....

[4]

7

- (v) Explain, in terms of particles, what happens to the rate of reaction when the temperature is increased.

.....

.....

.....

.....

..... [3]

- (e) Name the compound formed when sulfuric acid reacts with ammonia.

..... [1]

[Total: 16]

- 4 A student prepares magnesium sulfate crystals,  $\text{MgSO}_4$ , by adding excess magnesium to dilute sulfuric acid.

(a) Write the chemical equation for this reaction.

..... [1]

(b) Describe **two** observations which show the reaction has finished.

1 .....

2 ..... [2]

(c) The excess magnesium is removed by filtration.

State the general name given to a solid separated from a solution by filtration.

..... [1]

(d) The aqueous magnesium sulfate is heated until crystals begin to appear.

(i) Suggest the name for a solution in which no more solute can dissolve.

..... [1]

(ii) Suggest why more crystals of magnesium sulfate appear on cooling.

..... [1]

(e) Magnesium sulfate crystals have the formula,  $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ , where  $x$  is a whole number of molecules of water.

The student heats the crystals to remove the molecules of water.



(i) Name the term given to crystals containing molecules of water.

..... [1]



- (ii) The student heats a sample of  $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$  and finds it has lost 0.140 moles of  $\text{H}_2\text{O}$  and has 2.40 g of  $\text{MgSO}_4$  remaining.

Determine the value of  $x$ . Use the following steps.

- Calculate the  $M_r$  of  $\text{MgSO}_4$ .

$$M_r = \dots\dots\dots$$

- Determine the number of moles of  $\text{MgSO}_4$  formed.

$$\text{moles of MgSO}_4 \text{ formed} = \dots\dots\dots$$

- Determine the value of  $x$  in  $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ .

$$x = \dots\dots\dots$$

[3]

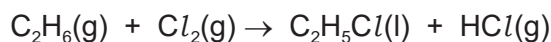
- (f) If the student uses dilute nitric acid instead of dilute sulfuric acid, the salt formed is magnesium nitrate,  $\text{Mg}(\text{NO}_3)_2$ .

Write the chemical equation for the reaction when solid magnesium nitrate is heated.

..... [2]

[Total: 12]

- 5 Ethane is an alkane which undergoes a photochemical reaction with chlorine as shown.



- (a) Write the general formula of alkanes.

..... [1]

- (b) State why this reaction is described as a photochemical reaction.

..... [1]

- (c) In this reaction, an atom of hydrogen is replaced with a chlorine atom.

State the name of this type of organic reaction.

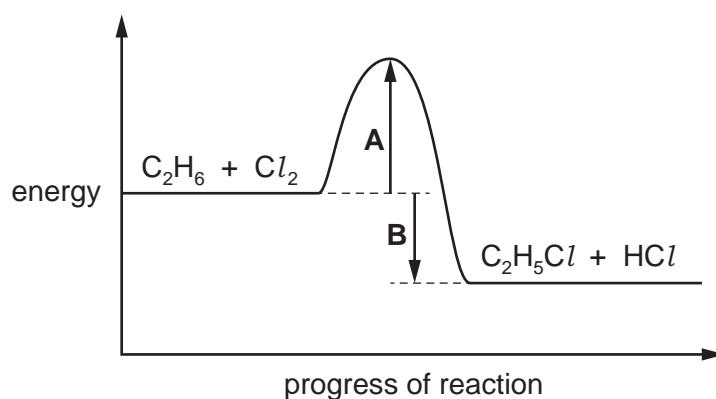
..... [1]

- (d) In this reaction, one of the products is chloroethane.

Name the other product.

..... [1]

- (e) The energy profile diagram of this reaction is shown.



- (i) Name the energy change labelled **A**.

..... [1]

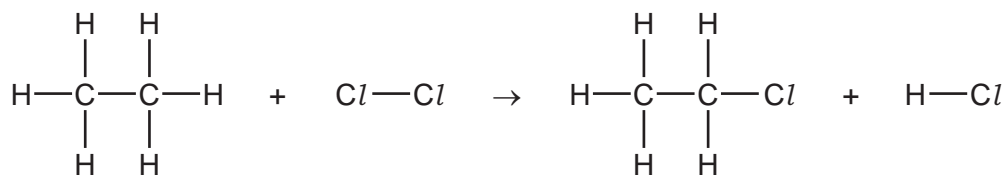
- (ii) Name the energy change labelled **B**.

..... [1]

- (iii) State how the energy profile diagram shows this is an exothermic reaction.

..... [1]

(f) The equation for the reaction can be represented as shown.



Some bond energies are given.

bond	bond energy /kJmol
C-H	410
C-C	350
Cl-Cl	240
C-Cl	340
H-Cl	430

Use the bond energies in the table to calculate the energy change in this reaction.

Use the following steps.

- Calculate the energy needed to break bonds.

energy = ..... kJ

- Calculate the energy released in making bonds.

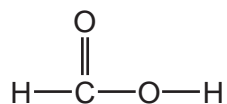
energy = ..... kJ

- Determine the energy change in this reaction.

energy change in this reaction = ..... kJ/mol  
[3]

[Total: 10]

6 A carboxylic acid **Y** has the structure shown.



(a) State the general formula of carboxylic acids.

..... [1]

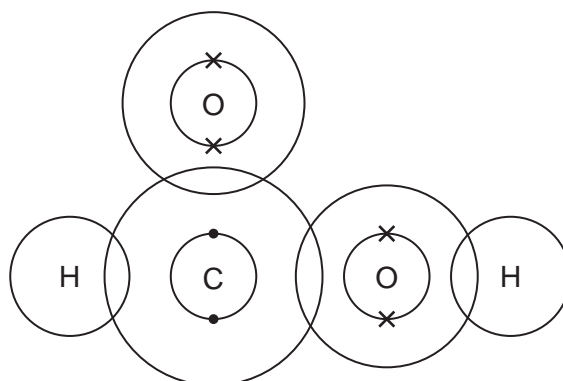
(b) Name carboxylic acid **Y**.

..... [1]

(c) Write the molecular formula of carboxylic acid **Y**.

..... [1]

(d) Complete the dot-and-cross diagram to show the arrangement of electrons in a molecule of carboxylic acid **Y**.



[3]

(e) Carboxylic acid **Y** will react with propan-1-ol,  $C_3H_7OH$ , to form ester **Z** and one other product.

(i) Name and draw the structure of ester **Z**.

Show all of the atoms and all of the bonds.

name .....

structure

[3]

(ii) Name the other product formed when carboxylic acid **Y** reacts with propan-1-ol.

..... [1]

(iii) Name:

- an ester which is a structural isomer of ester **Z**

.....

- a carboxylic acid which is a structural isomer of ester **Z**.

.....

[2]

[Total: 12]



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## The Periodic Table of Elements

		Group							
I	II	III	IV	V	VI	VII	VIII		
1	2	3	4	5	6	7	8	9	10
H hydrogen 1	He helium 4	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
<b>Key</b>									
atomic number atomic symbol name relative atomic mass									
3	4	11	12	13	14	15	16	17	18
Li lithium 7	Be beryllium 9	Na sodium 23	Mg magnesium 24	Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40
19	20	21	22	23	24	25	26	27	28
K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59
37	38	39	40	41	42	43	44	45	46
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium —	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106
55	56	57–71	72	73	74	75	76	77	78
Cs caesium 133	Ba barium 137	lanthanoids	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195
87	88	89–103	104	105	106	107	108	109	110
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
81	82	83	84	85	86	87	88	89	90
Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Cn copernicium —	Cu copper 64	Zn zinc 65	Ga gallium 70
113	114	115	116	117	118	119	120	121	122
Fl flerovium —	Lv livermorium —	Uu ununoctium —	Cv copernicium —	Nh nihonium —	Mc moscovium —	Lr lawrencium —	Ag silver 108	Cd cadmium 112	In indium 115
127	128	129	130	131	132	133	134	135	136
Ug unseptium —	Uu ununoctium —	Uu ununoctium —	Uu ununoctium —	Uu ununoctium —	Uu ununoctium —	Uu ununoctium —	Uu ununoctium —	Uu ununoctium —	Uu ununoctium —

lanthanoids

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

actinoids

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).