Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

CHEMISTRY **0971/21**

Paper 2 Multiple Choice (Extended) **May/June 2024**

45 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.

This document has **16** pages. Any blank pages are indicated.

1 A gas is heated. The pressure is kept constant.

Which statement describes the behaviour of the particles in the gas?

A The particles move faster and become closer together.

B The particles move faster and become further apart.

C The particles move more slowly and become closer together.

D The particles move more slowly and become further apart.

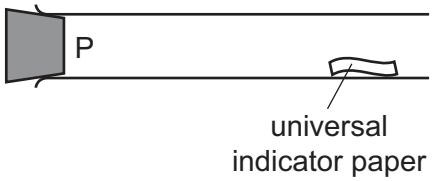
2 A mixture of ice and water is left to stand and the ice melts.

Which row describes what happens as the ice is melting?

	temperature of mixture	energy change
A	increases	average kinetic energy of particles decreases
B	increases	energy is used to overcome attractive forces
C	stays the same	average kinetic energy of particles decreases
D	stays the same	energy is used to overcome attractive forces

3 Hydrogen chloride gas [M_r: HC*l*, 36.5] is released at P in the apparatus shown.

The universal indicator paper turns red after 38 s.



The experiment is repeated using sulfur dioxide gas [M_r: SO_2, 64].

What is the result for sulfur dioxide gas?

	universal indicator paper turns	time for universal indicator paper to change colour / s
A	blue	26
B	blue	51
C	red	26
D	red	51

4 Four statements about atoms are listed.

1 The centre of an atom is positively charged.

2 Protons and electrons are located in the nucleus.

3 Protons and electrons have the same mass.

4 Most of the mass of an atom is in the nucleus.

Which statements are correct?

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

5 The electronic configurations of two elements are given.

element L: 2,8,8,1

element M: 2,8,4

Which row identifies the group number and the period number for element L and element M?

	element L		element M	
	group number	period number	group number	period number
A	I	4	IV	3
B	I	4	III	4
C	IV	1	III	4
D	IV	1	IV	3

6 Which statement explains why isotopes of the same element have the same chemical properties?

A They have different numbers of protons in their nucleus.

B They have different numbers of neutrons in their nucleus.

C They have the same electronic configuration.

D They have the same number of electrons as protons.

[Turn over

7 Which statements about potassium chloride are correct?

1 It conducts electricity when solid because its ions are free to move.
2 It has a high melting point because it has strong intermolecular forces.
3 Its structure is a giant lattice of alternating positive and negative ions.
4 It is soluble in water.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

8 How many electrons are shared in **one** molecule of nitrogen and in **one** molecule of ethene?

	nitrogen	ethene
A	2	12
B	2	8
C	6	12
D	6	8

9 What is the total number of electrons in **one** molecule of ammonia, NH_3?

A 6 **B** 8 **C** 10 **D** 11

10 When heated, copper(II) oxide, CuO, reacts with ammonia, NH_3.

$$3CuO + 2NH_3 \rightarrow 3Cu + N_2 + 3H_2O$$

8.5 g of ammonia reacts with an excess of copper(II) oxide to produce 26.4 g of copper.

What is the percentage yield of copper in this reaction?

A 27.5% **B** 32.2% **C** 55.0% **D** 82.5%

11 What is the empirical formula of ethanoic acid?

A CHO **B** CH_2O **C** C_2H_2O **D** $C_2H_4O_2$

12 Magnesium chloride, $MgCl_2$, contains magnesium ions and chloride ions.

How many chloride ions are present in **two** moles of magnesium chloride?

A 6.02×10^{23}

B 1.204×10^{24}

C 2.408×10^{24}

D 3.612×10^{24}

13 A metal object is electroplated with copper.

One electrode is the metal object and the other electrode is copper. The electrolyte is aqueous copper(II) sulfate.

Which row shows the ionic half-equation for the reaction at the anode and the observation of the electrolyte?

	anode	electrolyte
A	$Cu^{2+} + 2e^- \rightarrow Cu$	blue colour fades
B	$Cu^{2+} + 2e^- \rightarrow Cu$	blue colour does not change
C	$Cu \rightarrow Cu^{2+} + 2e^-$	blue colour fades
D	$Cu \rightarrow Cu^{2+} + 2e^-$	blue colour does not change

14 Which statement about electrolysis is correct?

A Chemical energy is converted to electrical energy.

B Electrons flow through the electrolyte.

C Ionic compounds are broken down.

D Metals are formed at the positive electrode.

[Turn over

15 The reaction between hydrogen and oxygen releases 486 kJ / mol of energy.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

The bond energy of H–H is 436 kJ / mol and that of H–O is 464 kJ / mol.

What is the bond energy of O=O?

A 430 kJ / mol

B 458 kJ / mol

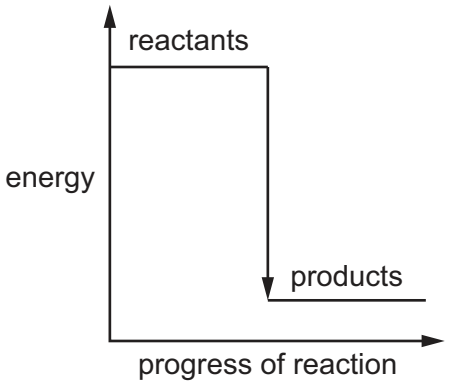
C 498 kJ / mol

D 984 kJ / mol

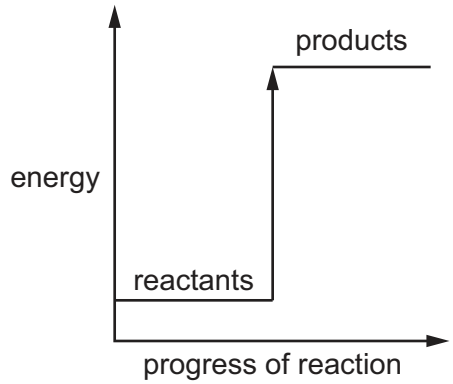
16 Which reaction pathway diagram shows the reaction that will give out the most energy?

The scale on the *y*-axis is the same in each diagram.

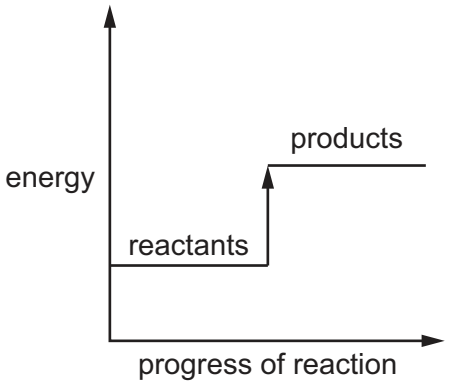
A



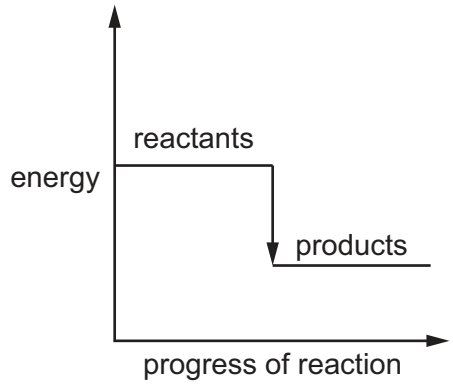
B



C



D



17 When calcium carbonate is heated strongly, a gas is given off.

Which word describes this change?

A chemical

B exothermic

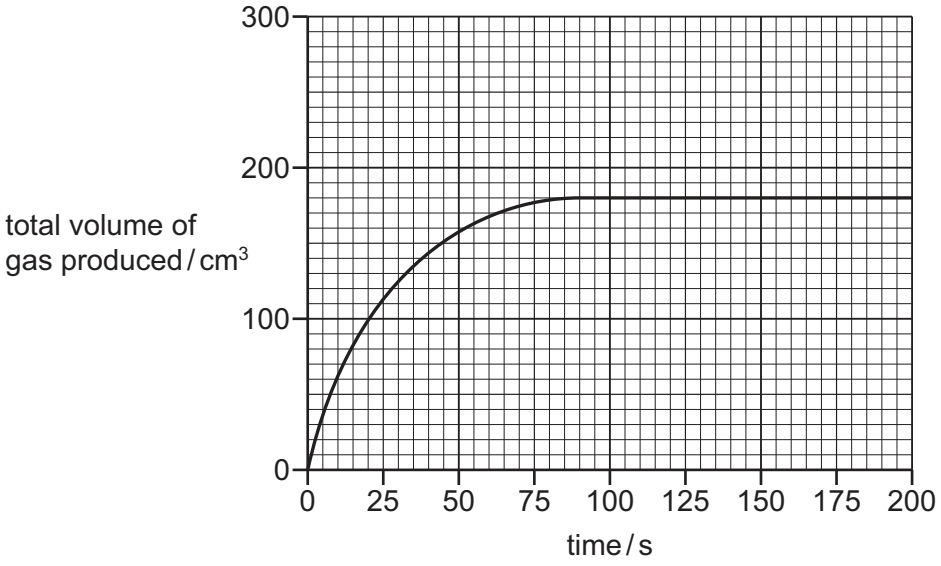
C physical

D reduction

18 Powdered magnesium carbonate is added to excess dilute hydrochloric acid.

The total volume of gas produced is measured over time.

A graph of the results is shown.



The experiment is repeated but the concentration of the hydrochloric acid is doubled.

All other conditions are kept the same.

Which statements about the second experiment are correct?

1 The final volume of gas is 360 cm^3.

2 The reaction finishes before 90 seconds.

3 The activation energy of the reaction is lower.

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 2 only

19 Which statements explain why increasing the temperature changes the rate of a chemical reaction?

1 It increases the activation energy.

2 It increases the frequency of collisions between the reacting particles.

3 It increases the kinetic energy of the reacting particles.

4 It increases the number of particles per unit volume.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

20 Hydrogen is made by reacting carbon with steam. The equation for the reaction is shown.

$$C(s) + H_2O(g) \rightleftharpoons H_2(g) + CO(g)$$

The forward reaction is endothermic.

Which row describes changes in the pressure and the temperature that will **both** shift the position of equilibrium to the right?

	pressure	temperature
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

21 Which row shows the conditions used for the conversion of sulfur dioxide to sulfur trioxide in the Contact process?

	pressure / atm	temperature / °C	catalyst
A	250	200	vanadium(V) oxide
B	2	450	vanadium(V) oxide
C	250	200	iron
D	2	450	iron

22 The equation for the reaction of magnesium with carbon dioxide is shown.

$$2Mg + CO_2 \rightarrow 2MgO + C$$

Which statement about this reaction is correct?

A Magnesium is oxidised and carbon dioxide is reduced.

B Magnesium is reduced and carbon dioxide is oxidised.

C Magnesium and carbon dioxide are both oxidised.

D Magnesium and carbon dioxide are neither oxidised nor reduced.

23 Chlorine displaces bromine from aqueous potassium bromide.

The ionic equation for the reaction is shown.

$$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$$

Which statement about this reaction is correct?

A Bromide ions act as an oxidising agent.

B Bromide ions are oxidised as electrons are lost.

C Chlorine acts as a reducing agent.

D Chlorine is reduced as electrons are lost.

24 Which gas is produced when ammonium chloride is warmed with aqueous sodium hydroxide?

A ammonia

B chlorine

C hydrogen

D nitrogen

25 Which equation represents a solution of ethanoic acid in water?

A $HCOOH(aq) \rightleftharpoons HCOO^-(aq) + H^+(aq)$

B $HCOOH(aq) \rightarrow HCOO^-(aq) + H^+(aq)$

C $CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$

D $CH_3COOH(aq) \rightarrow CH_3COO^-(aq) + H^+(aq)$

[Turn over

26 Four statements about the reactions of oxides with dilute hydrochloric acid and with aqueous sodium hydroxide are listed.

1 Aluminium oxide reacts with both dilute hydrochloric acid and aqueous sodium hydroxide.

2 Calcium oxide reacts with both dilute hydrochloric acid and aqueous sodium hydroxide.

3 Copper(II) oxide reacts with dilute hydrochloric acid but **not** with aqueous sodium hydroxide.

4 Sulfur dioxide does **not** react with either dilute hydrochloric acid or aqueous sodium hydroxide.

Which statements are correct?

A 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

27 Which statement about elements in Period 3 of the Periodic Table is correct?

A Aluminium is a non-metal in Group III.

B Argon is in Group VIII and has eight electrons in its outer electron shell.

C Magnesium is in Group II and has three electrons in its outer electron shell.

D Sulfur is a metal in Group VI.

28 Which row describes the structure of Group VII elements and the trend in their reactivity down the group?

	structure	reactivity down Group VII
A	diatomic	increases
B	diatomic	decreases
C	monatomic	increases
D	monatomic	decreases

29 Some information about four elements, P, Q, R and S, is shown.

	melting point in °C	density in g / cm^3	colour of chloride
P	1247	7.43	pink
Q	1410	2.33	white
R	1910	6.11	purple
S	115	2.07	red

Which elements are transition elements?

A P and R **B** P and S **C** Q and R **D** R and S

30 Propanoic acid is a carboxylic acid. It has similar chemical properties to ethanoic acid.

Which statements are correct?

1 Aqueous propanoic acid is a weaker acid than dilute hydrochloric acid.
2 Propanoic acid partially ionises in aqueous solution.
3 Propanoic acid reacts with ethanol to form propyl ethanoate.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

31 Iron rusts in the presence of oxygen and water.

Which statements about the rusting of iron are correct?

1 Anhydrous iron(II) oxide is produced when iron rusts.
2 Iron rusts more quickly when attached to a piece of zinc.
3 Coating the iron with plastic prevents the iron from rusting.
4 Iron loses electrons when it rusts.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

32 An iron nail is added to aqueous copper(II) sulfate and a different iron nail is added to aqueous magnesium sulfate.

The results are shown.

experiment	result
iron nail in aqueous copper(II) sulfate	nail is coated with a brown solid
iron nail in aqueous magnesium sulfate	no reaction

Which statement is correct?

A Copper atoms are oxidised more easily than magnesium atoms.

B Copper atoms are reduced more easily than iron ions.

C Iron atoms are oxidised more easily than copper atoms.

D Iron atoms are reduced more easily than copper ions.

33 Which pollutant leads to the deoxygenation of water in ponds and lakes?

A fertilisers containing nitrates and phosphates

B toxic metal compounds

C combustion products of fossil fuels

D acid rain

34 Which statement identifies a sample of water as pure?

A It melts at room temperature.

B It turns anhydrous copper(II) sulfate blue.

C It turns hydrated cobalt(II) chloride from blue to pink.

D It boils at 100 °C.

35 Oxides of nitrogen are produced by car engines.

In a catalytic converter oxides of nitrogen are removed by reacting them with compound X.

Which row describes the type of reaction oxides of nitrogen undergo and identifies compound X?

	type of reaction	compound X
A	oxidation	carbon dioxide
B	oxidation	carbon monoxide
C	reduction	carbon dioxide
D	reduction	carbon monoxide

36 What is a disadvantage of producing ethanol using the catalytic addition of steam to ethene?

A the energy cost is low

B the process is continuous

C the process uses a non-renewable raw material

D the ethanol is pure

37 Which statement about the polymer PET is correct?

A It can be broken down into its monomers and re-polymerised.

B It is an addition polymer.

C It is a polyamide.

D It is made from amino acid monomers.

[Turn over

38 The formulae of five compounds are listed.

1 C_4H_{10}

2 C_2H_5OH

3 C_4H_9OH

4 C_4H_9COOH

5 $C_5H_{11}OH$

Which compounds are in the same homologous series?

A 1, 3 and 4

B 2, 3 and 5

C 3 and 4 only

D 3 and 5 only

39 Propane reacts with chlorine.

Which statements about this reaction are correct?

1 Ultraviolet light is used to provide the activation energy.

2 Propane undergoes an addition reaction.

3 One of the products is CH_3CH_2Cl.

4 One of the products is HCl.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

40 Which statement about chromatography is correct?

A It is **not** possible for two different substances to have the same R_f value.

B It is only possible to use chromatography on substances which have a colour.

C It is possible to use chromatography on colourless substances using a locating agent.

D The R_f value of a substance = $\frac{\text{the distance travelled by the solvent}}{\text{the distance travelled by the substance}}$

BLANK PAGE

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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).