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Cambridge Assessment International Education

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5656332582

CHEMISTRY **0620/41**

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.

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1 The names of the elements of Period 2 of the Periodic Table are shown.

lithium beryllium boron carbon nitrogen oxygen fluorine neon

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

Identify the element which:

(a) is a product of photosynthesis

..... [1]

(b) has an oxide found in clean, dry air

..... [1]

(c) forms a basic oxide with the formula X_2O

..... [1]

(d) is a main component of fertilisers used to improve crop growth

..... [1]

(e) has the highest rate of diffusion at room temperature

..... [1]

(f) produces a red flame in a flame test

..... [1]

(g) has only 5 electrons in each of its atoms

..... [1]

(h) has an oxide responsible for acid rain.

..... [1]

[Total: 8]

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2 Potassium is a Group I element.

(a) Name and describe the bonding in potassium.

name .....

description .....

.....

.....

.....

[4]

(b) Potassium combines with sulfur to form an ionic compound, potassium sulfide, K_2S.

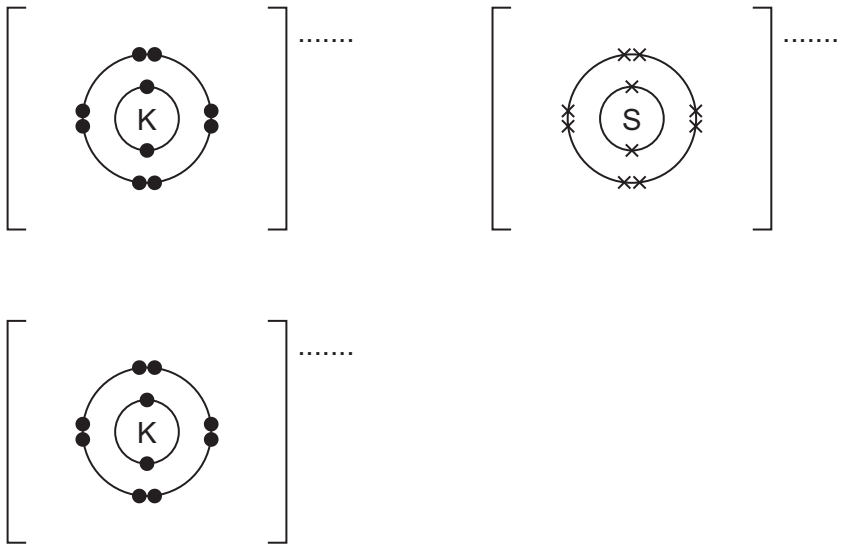
(i) Give **two** physical properties of ionic compounds.

1 .....

2 .....

[2]

(ii) Complete the dot-and-cross diagram to show the electron arrangement and charges of the ions in potassium sulfide.



.....

.....

.....

[3]

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(c) When potassium is added to water, it reacts vigorously and a coloured flame is seen. The equation for the reaction is shown.

$$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$$

(i) State the colour of the flame seen.

..... [1]

(ii) The solution formed is potassium hydroxide, a strong alkali.

State the formula of the ion responsible for alkalinity in a solution.

..... [1]

(iii) State the colour of litmus in a strong alkali.

..... [1]

(iv) Calculate the volume, in cm^3, of hydrogen gas formed when 2.34 g of potassium is added to excess water at room temperature and pressure.

Use the following steps.

- Calculate the number of moles of potassium added.

= ..... mol

- Determine the number of moles of hydrogen gas formed.

= ..... mol

- Calculate the volume of hydrogen gas formed.

volume = ... cm^3
[3]

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(d) Aqueous potassium hydroxide reacts with a dilute acid to produce aqueous potassium chloride, KC*l*(aq), which is a salt.

(i) Name the dilute acid used.

..... [1]

(ii) State the type of reaction taking place.

..... [1]

(iii) Name the experimental technique used when salts are made by reacting a dilute acid with an aqueous alkali.

..... [1]

(e) When aqueous silver nitrate, $AgNO_3$(aq), is added to aqueous potassium chloride, a precipitate is formed.

(i) State the colour of the precipitate formed.

..... [1]

(ii) Name the precipitate formed.

..... [1]

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

..... [3]

[Total: 23]

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3 Ammonia is made in an industrial process starting with nitrogen. The equation for the reaction is shown.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(a) Name the industrial process used to make ammonia.

..... [1]

(b) State the raw material from which nitrogen is obtained.

..... [1]

(c) State what is meant by the symbol $\rightleftharpoons$.

..... [1]

(d) State the temperature and pressure used in this industrial process.

temperature = ... °C

pressure = ... atm
[2]

(e) Name the catalyst used in this industrial process.

..... [1]

(f) The forward reaction is exothermic.

State the effect, if any, on the position of the equilibrium when the following changes are made. Explain your answers.

temperature is reduced

.....

.....

pressure is reduced

.....

.....
[4]

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(g) Explain, in terms of particles, what happens to the rate of reaction when the temperature is reduced.

.....

.....

.....

.....

..... [3]

(h) Give the formula of the compound formed when sulfuric acid reacts with ammonia.

..... [1]

[Total: 14]

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4 A student prepares calcium nitrate, $Ca(NO_3)_2$, by adding calcium carbonate to dilute nitric acid.

(a) Write the chemical equation for this reaction.

..... [2]

(b) Describe **two** observations during this reaction.

1 .....

2 .....
[2]

(c) The student continues to add calcium carbonate until it is in excess. The student then removes the excess calcium carbonate by filtration and collects the aqueous calcium nitrate.

State the general term given to a solution collected from filtration.

..... [1]

(d) The student gently heats the aqueous calcium nitrate until the solution is saturated.

(i) Suggest what is meant by the term *saturated solution*.

.....

..... [2]

(ii) Describe how crystals are produced from a hot saturated solution.

..... [1]

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(e) Calcium nitrate crystals are hydrated and have the formula $Ca(NO_3)_2 \cdot xH_2O$ where x is a whole number of molecules of water.

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

$$Ca(NO_3)_2 \cdot xH_2O(s) \rightarrow Ca(NO_3)_2(s) + xH_2O(g)$$

(i) State the term used to describe the calcium nitrate after the molecules of water have been removed.

..... [1]

(ii) The student heats a sample of $Ca(NO_3)_2 \cdot xH_2O$ and forms 2.46 g of $Ca(NO_3)_2$ and 0.0600 moles of H_2O.

Determine the value of x. Use the following steps.

- Calculate the M_r of $Ca(NO_3)_2$.

M_r = ...

- Determine the number of moles of $Ca(NO_3)_2$ formed.

moles of $Ca(NO_3)_2$ formed = ...

- Determine the value of x in $Ca(NO_3)_2 \cdot xH_2O$.

x = ...
[3]

(f) Nitrates decompose on heating.

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

..... [2]

[Total: 14]

5 Ethene is an alkene which reacts with bromine as shown in the equation.

$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

(a) Write the general formula of alkenes.

..... [1]

(b) Describe the colour change seen when ethene is bubbled through aqueous bromine.

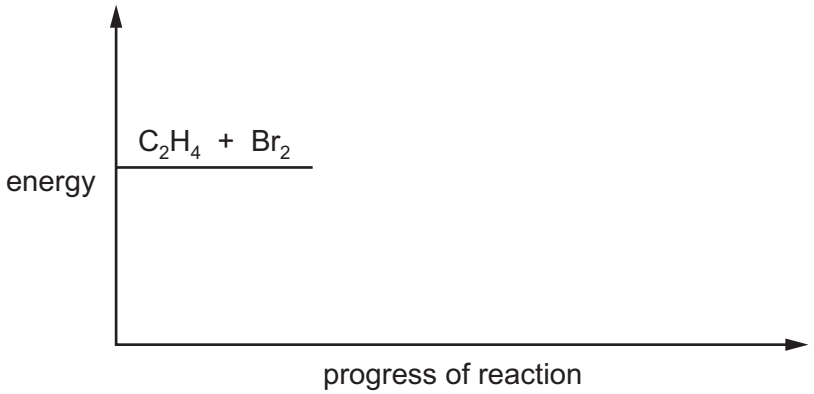
from ..... to ..... [1]

(c) In this reaction only one product is formed from two reactants.

Name this type of organic reaction.

..... [1]

(d) Part of the energy profile diagram of this reaction is shown.



(i) The reaction is exothermic.

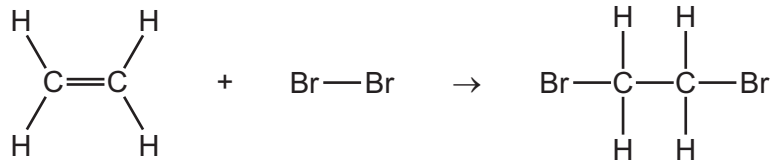
Complete the energy profile diagram for this reaction.
Include:

- the position of the products
- an arrow to show the activation energy, labelled as A
- an arrow to show the energy change for the reaction.

[3]

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



Some bond energies are given.

bond	bond energy / kJ mol
C–H	410
C=C	610
Br–Br	190
C–C	350
C–Br	290

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

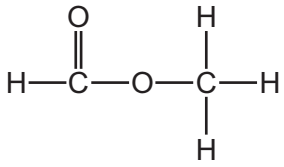
- Determine the energy change in this reaction.

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

[Total: 9]

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6 Ester **Y** has the structure shown.



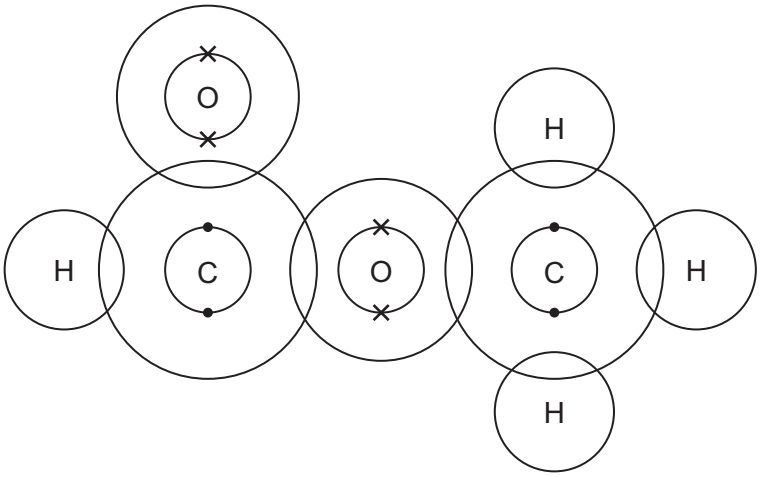
(a) (i) Name ester **Y**.

..... [1]

(ii) Deduce the empirical formula of ester **Y**.

..... [1]

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



[3]

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(c) Ester **Y** can be made by reacting two organic compounds together.

Name the compounds and draw their structures.

Show all of the atoms and all of the bonds.

name .....

structure

name .....

structure

[4]

(d) (i) Describe what is meant by the term *structural isomer*.

.....

..... [2]

(ii) Name a carboxylic acid which is a structural isomer of ester **Y**.

..... [1]

[Total: 12]

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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.).

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