Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

4902701477

CHEMISTRY **0620/42**

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.

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, Na_2O.

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

..... [1]

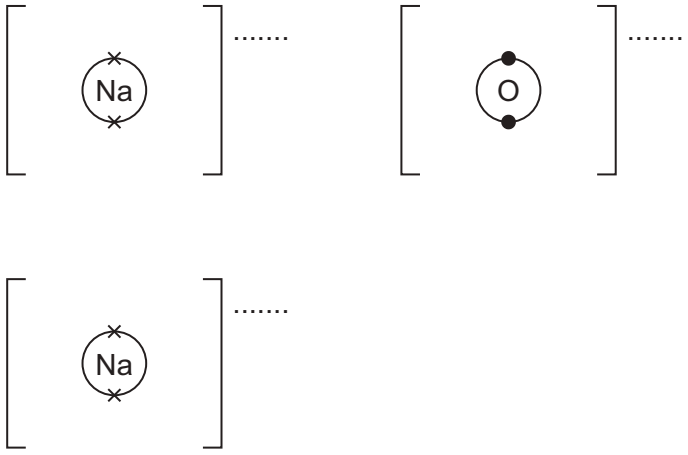
(ii) State the colour of the flame seen when sodium burns.

..... [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.

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

Calculate the concentration of NaOH(aq) formed, in g/dm^3, when 0.345 g of sodium is added to 50.0 cm^3 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^3.

concentration of NaOH = ... mol/dm^3

- Determine the M_r of NaOH and calculate the concentration of NaOH in g/dm^3.

concentration of NaOH = ... g/dm^3
[5]

(d) When NaOH(aq) is added to aqueous iron(III) chloride, $FeCl_3$(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]

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.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(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]

(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, $MgSO_4$, 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, $MgSO_4 \bullet xH_2O$, where x is a whole number of molecules of water.

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

$$MgSO_4 \bullet xH_2O(s) \rightarrow MgSO_4(s) + xH_2O(g)$$

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

..... [1]

(ii) The student heats a sample of $MgSO_4 \cdot xH_2O$ and finds it has lost 0.140 moles of H_2O and has 2.40 g of $MgSO_4$ remaining.

Determine the value of x. Use the following steps.

- Calculate the M_r of $MgSO_4$.

M_r = ...

- Determine the number of moles of $MgSO_4$ formed.

moles of $MgSO_4$ formed = ...

- Determine the value of x in $MgSO_4 \cdot xH_2O$.

x = ...
[3]

(f) If the student uses dilute nitric acid instead of dilute sulfuric acid, the salt formed is magnesium nitrate, $Mg(NO_3)_2$.

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.

$$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(l) + HCl(g)$$

(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.

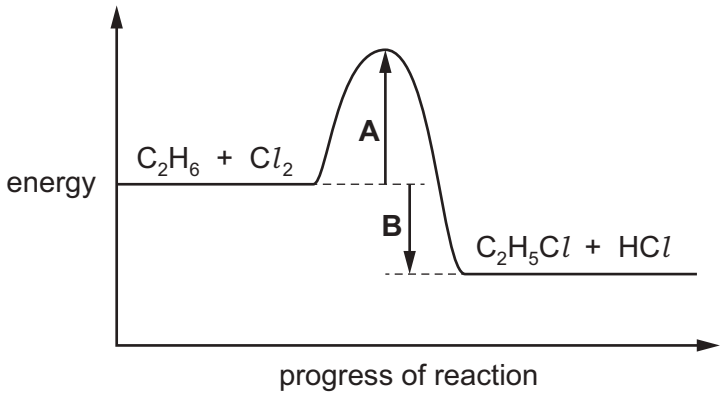
..... [1]

(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]

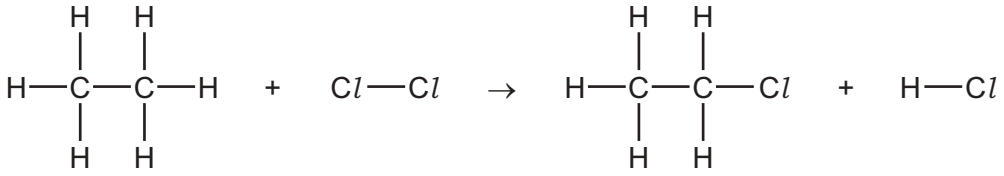
(ii) Name the energy change labelled **B**.

..... [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 / kJ mol
C–H	410
C–C	350
C*l*–C*l*	240
C–C*l*	340
H–C*l*	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.

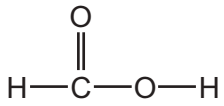
energy = ... kJ

- 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]

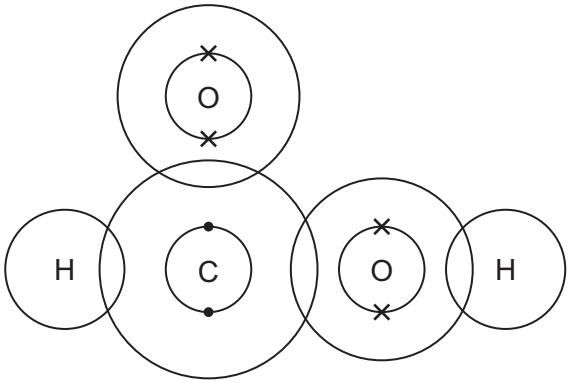
(b) Name carboxylic acid **Y**.

..... [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]

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.).