



# Cambridge IGCSE™

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**CHEMISTRY**

**0620/42**

Paper 4 Theory (Extended)

**October/November 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.

1 This question is about states of matter.

(a) Complete the table, using ticks (✓) and crosses (✗), to describe the properties of gases, liquids and solids.

state of matter	particles are touching	particles have random movement	particles are regularly arranged
gas			
liquid			
solid			

[3]

(b) Substances can change state.

(i) Boiling and evaporation are two ways in which a liquid changes into a gas.

Describe **two** differences between boiling and evaporation.

1 .....

2 ..... [2]

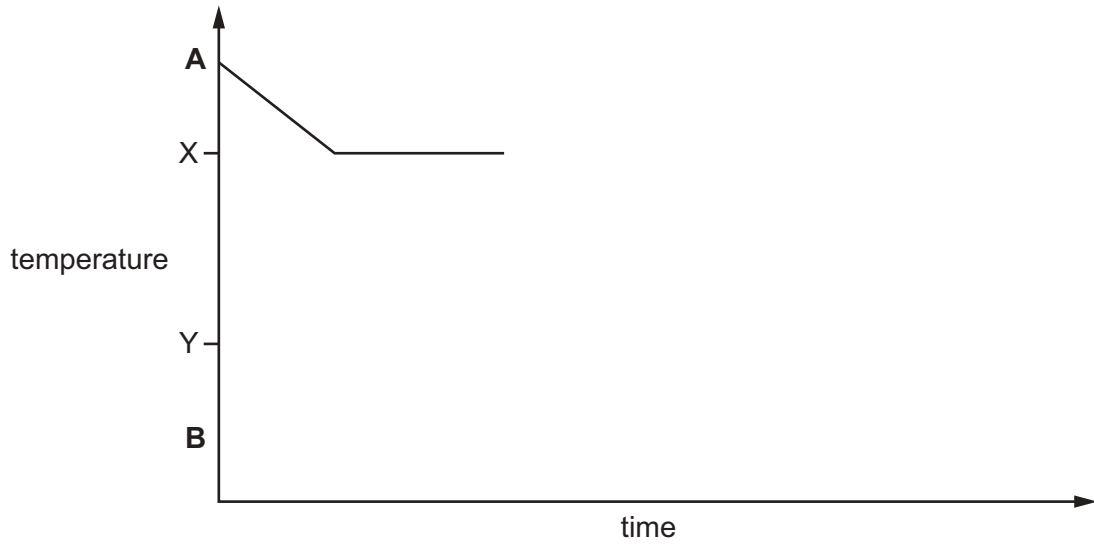
(ii) Name the change of state when:

• a gas becomes a liquid .....

• a solid becomes a gas. .... [2]

(c) A substance boils at temperature X and melts at temperature Y.

Complete the graph to show the change in temperature over time as the substance cools from temperature A to temperature B.



[2]

(d) A solution is a mixture of a solute and a solvent.

(i) Name the process when a solid substance mixes with a solvent to form a solution.

..... [1]

(ii) Name the type of reaction when two solutions react to form an insoluble substance.

..... [1]

[Total: 11]

2 Acids are important laboratory chemicals.

(a) Some acids completely dissociate in water to form ions.

(i) State the term applied to acids that completely dissociate in water.

..... [1]

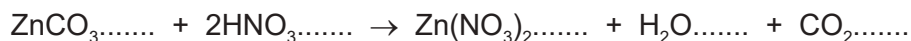
(ii) Complete the equation to show the complete dissociation of sulfuric acid in water.



(iii) State the colour of methyl orange in sulfuric acid.

..... [1]

(b) The equation for the reaction between powdered zinc carbonate and dilute nitric acid is shown.



(i) Complete the equation by adding state symbols. [2]

(ii) A student found that 2.5g of zinc carbonate required 20 cm<sup>3</sup> of dilute nitric acid to react completely.

Calculate the concentration of dilute nitric acid using the following steps:

- calculate the mass of 1 mole of ZnCO<sub>3</sub>

..... g

- calculate the number of moles of ZnCO<sub>3</sub> reacting

..... moles

- determine the number of moles of HNO<sub>3</sub> reacting

..... moles

- calculate the concentration of HNO<sub>3</sub>.

..... mol/dm<sup>3</sup>  
[4]

[Total: 10]

3 Atoms contain protons, neutrons and electrons.

(a) Complete the table to show the relative mass and the relative charge of a proton, a neutron and an electron.

	relative mass	relative charge
proton		
neutron		
electron	$\frac{1}{1840}$	

[3]

(b) The table shows the number of protons, neutrons and electrons in some atoms and ions.

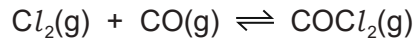
Complete the table.

atom or ion	number of protons	number of neutrons	number of electrons
${}^{32}_{16}\text{S}$			
${}^{39}_{19}\text{K}^+$			
	35	44	36

[5]

[Total: 8]

- 4 Chlorine reacts with carbon monoxide to produce phosgene gas,  $\text{COCl}_2(\text{g})$ . A catalyst is used.



The reaction is exothermic.

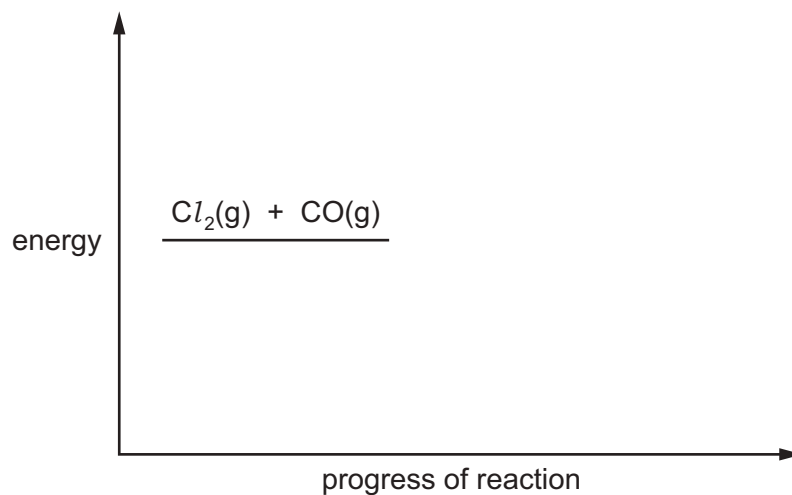
- (a) Explain why the reaction is exothermic in terms of the energy changes of bond breaking and bond making.

.....  
 .....  
 ..... [3]

- (b) (i) Complete the energy level diagram for this reaction.

On your diagram show:

- the product of the reaction
- an arrow representing the energy change, labelled  $\Delta H$
- an arrow representing the activation energy, labelled A.



[3]

- (ii) State why a catalyst is used.

..... [1]

(c) Describe and explain the effect, if any, on the position of equilibrium when:

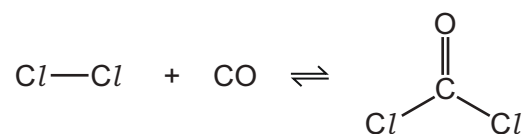
(i) the pressure is increased

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

(ii) the temperature is increased.

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

(d) The reaction between chlorine and carbon monoxide can be represented as shown.



When one mole of chlorine reacts with one mole of carbon monoxide, 230 kJ of energy is released.

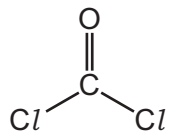
Some bond energies are shown in the table.

bond	bond energy in kJ/mol
Cl-Cl	240
C=O	745
C-Cl	400

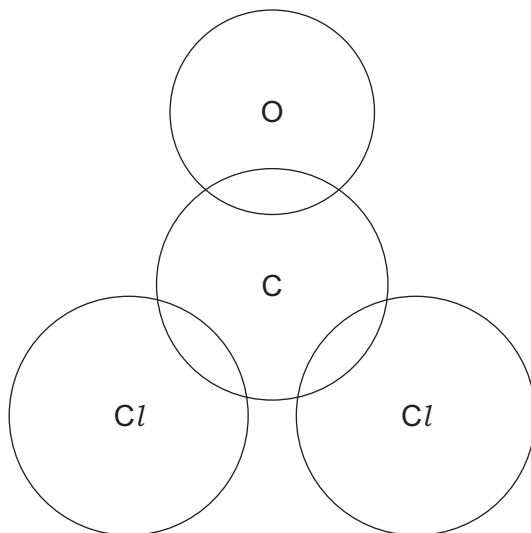
Use the information to calculate the energy of the bond between the C and the O in carbon monoxide, CO.

bond energy in carbon monoxide, CO = ..... kJ/mol [3]

(e) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of  $\text{COCl}_2$ .



Show outer electrons only.



[3]

[Total: 17]



5 Iron is a transition element. Potassium is a Group I element.

(a) Iron and potassium have the same type of bonding.

Name and describe the type of bonding in these two elements.

name .....

description .....

.....

.....

.....

[4]

(b) Transition elements and Group I elements have some similar physical properties.

They can both:

- be hammered into a shape
- conduct electricity
- be stretched into wires.

(i) Name the term used to describe the ability of elements to be hammered into a shape.

..... [1]

(ii) Describe what happens to the particles in iron when it is hammered into a shape.

.....

..... [1]

(iii) Suggest why copper, rather than other transition elements, is used for wires which conduct electricity.

..... [1]

(c) Transition elements are harder and stronger than Group I elements.

Describe how **two** other **physical** properties of transition elements are different from those of Group I elements.

1 .....

2 .....

[2]

(d) Chemical properties of some Group I elements are shown in the table.

element	reaction with cold water	reaction with oxygen	flame test colour
lithium	<ul style="list-style-type: none"> <li>steadily effervesces</li> <li>forms a colourless solution</li> </ul>	very slowly forms an oxide layer	red
sodium	<ul style="list-style-type: none"> <li>strongly effervesces</li> <li>forms a colourless solution</li> </ul>	slowly forms an oxide layer	
potassium	<ul style="list-style-type: none"> <li>very strongly effervesces</li> <li>forms a colourless solution</li> </ul>	quickly forms an oxide layer	
rubidium			ruby red

(i) Add to the table:

- the flame test colours for sodium and potassium
- the predicted reactions of rubidium with water and with oxygen.

[4]

(ii) Name the gas produced when Group I elements react with water.

..... [1]

(iii) Name the solution formed when potassium reacts with water.

..... [1]

(iv) Predict the pH of the colourless solution formed when potassium reacts with water.

..... [1]

(v) Write the chemical equation for the reaction of sodium with oxygen.

..... [2]

(e) Iron is a typical transition element. It is the catalyst used in the Haber process.

(i) Write the equation for the reaction that occurs in the Haber process.

..... [2]

(ii) State the temperature and pressure used in the Haber process. Include units.

temperature .....

pressure .....

[2]

[Total: 22]

6 Ethanol,  $C_2H_5OH$ , belongs to the homologous series called alcohols.

(a) Write the general formula of alcohols.

..... [1]

(b) Explain why ethanol **cannot** be described as a hydrocarbon.

..... [1]

(c) Ethanol can be manufactured from different substances by reaction with steam or by fermentation.

(i) Give the formula of the substance which reacts with steam to form ethanol.

..... [1]

(ii) Name a substance which will undergo fermentation to form ethanol.

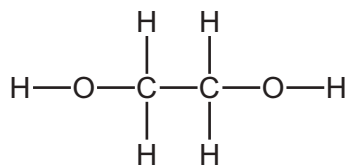
..... [1]

(d) Ethanol is a fuel.

Write the chemical equation for the complete combustion of ethanol.

..... [2]

(e) Ethane-1,2-diol has two alcohol functional groups.



One molecule of ethane-1,2-diol will react with two molecules of ethanoic acid to form molecule **X**.

**X** has two ester functional groups and a molecular formula of  $\text{C}_6\text{H}_{10}\text{O}_4$ .

(i) State the empirical formula of **X**.

..... [1]

(ii) Draw the structure of **X**.

Show all of the atoms and all of the bonds.

[2]

(iii) Name the **other** substance formed in this reaction.

..... [1]

(f) Each alcohol functional group in ethane-1,2-diol reacts with acidified potassium manganate(VII) to form a different organic compound, **Y**.

(i) Name the functional groups formed in **Y**.

..... [1]

(ii) Draw the structure of **Y**.

Show all of the atoms and all of the bonds.

[1]

[Total: 12]





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## The Periodic Table of Elements

Group																																																																																			
I	II	III	IV	V	VI	VII	VIII																																																																												
1 <b>H</b> hydrogen 1	2 <b>He</b> helium 4																																																																																		
<b>Key</b> atomic number atomic symbol name relative atomic mass																																																																																			
3 <b>Li</b> lithium 7	4 <b>Be</b> beryllium 9	5 <b>B</b> boron 11	6 <b>C</b> carbon 12	7 <b>N</b> nitrogen 14	8 <b>O</b> oxygen 16	9 <b>F</b> fluorine 19	10 <b>Ne</b> neon 20	11 <b>Na</b> sodium 23	12 <b>Mg</b> magnesium 24	13 <b>Al</b> aluminium 27	14 <b>Si</b> silicon 28	15 <b>P</b> phosphorus 31	16 <b>S</b> sulfur 32	17 <b>Cl</b> chlorine 35.5	18 <b>Ar</b> argon 40	19 <b>K</b> potassium 39	20 <b>Ca</b> calcium 40	21 <b>Sc</b> scandium 45	22 <b>Ti</b> titanium 48	23 <b>V</b> vanadium 51	24 <b>Cr</b> chromium 52	25 <b>Mn</b> manganese 55	26 <b>Fe</b> iron 56	27 <b>Co</b> cobalt 59	28 <b>Ni</b> nickel 59	29 <b>Cu</b> copper 64	30 <b>Zn</b> zinc 65	31 <b>Ga</b> gallium 70	32 <b>Ge</b> germanium 73	33 <b>As</b> arsenic 75	34 <b>Se</b> selenium 79	35 <b>Br</b> bromine 80	36 <b>Kr</b> krypton 84	37 <b>Rb</b> rubidium 85	38 <b>Sr</b> strontium 88	39 <b>Y</b> yttrium 89	40 <b>Zr</b> zirconium 91	41 <b>Nb</b> niobium 93	42 <b>Mo</b> molybdenum 96	43 <b>Tc</b> technetium —	44 <b>Ru</b> ruthenium 101	45 <b>Rh</b> rhodium 103	46 <b>Pd</b> palladium 106	47 <b>Ag</b> silver 108	48 <b>Cd</b> cadmium 112	49 <b>In</b> indium 115	50 <b>Sn</b> tin 119	51 <b>Sb</b> antimony 122	52 <b>Te</b> tellurium 128	53 <b>I</b> iodine 127	54 <b>Xe</b> xenon 131	55 <b>Cs</b> caesium 133	56 <b>Ba</b> barium 137	57–71 lanthanoids	72 <b>Hf</b> hafnium 178	73 <b>Ta</b> tantalum 181	74 <b>W</b> tungsten 184	75 <b>Re</b> rhenium 186	76 <b>Os</b> osmium 190	77 <b>Ir</b> iridium 192	78 <b>Pt</b> platinum 195	79 <b>Au</b> gold 197	80 <b>Hg</b> mercury 201	81 <b>Tl</b> thallium 204	82 <b>Pb</b> lead 207	83 <b>Bi</b> bismuth 209	84 <b>Po</b> polonium —	85 <b>At</b> astatine —	86 <b>Rn</b> radon —	87 <b>Fr</b> francium —	88 <b>Ra</b> radium —	89–103 actinoids	104 <b>Rf</b> rutherfordium —	105 <b>Db</b> dubnium —	106 <b>Sg</b> seaborgium —	107 <b>Bh</b> bohrium —	108 <b>Hs</b> hassium —	109 <b>Mt</b> meitnerium —	110 <b>Ds</b> darmstadtium —	111 <b>Rg</b> roentgenium —	112 <b>Cn</b> copernicium —	114 <b>Fl</b> flerovium —	116 <b>Lv</b> livermorium —

lanthanoids

actinoids

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

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