Cambridge Assessment International Education

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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.

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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.

View solution

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

[3]

(b) Substances can change state.

View solution

(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:

View solution

- 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**.

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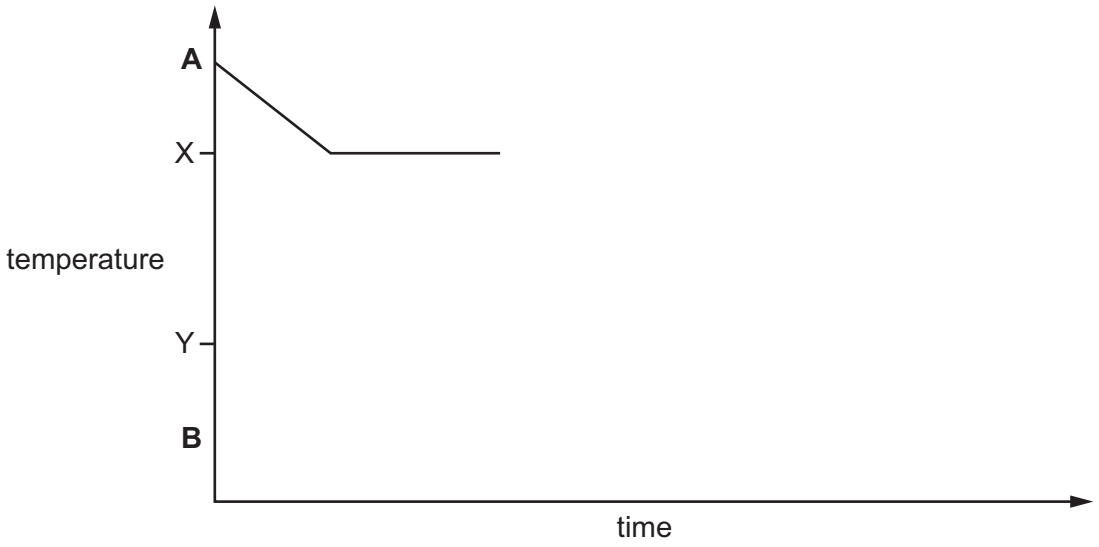

[2]

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(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]

View solution

2 Acids are important laboratory chemicals.

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

View solution

(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.

$H_2SO_4 \rightarrow$ ..... [2]

(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.

$ZnCO_3$..... + $2HNO_3$..... $\rightarrow$ $Zn(NO_3)_2$..... + H_2O..... + CO_2.....

View solution

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

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

View solution

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

- calculate the mass of 1 mole of $ZnCO_3$

..... g

- calculate the number of moles of $ZnCO_3$ reacting

..... moles

- determine the number of moles of HNO_3 reacting

..... moles

- calculate the concentration of HNO_3.

..... mol/dm^3
[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.

View solution

	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.

View solution

Complete the table.

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

[5]

[Total: 8]

4 Chlorine reacts with carbon monoxide to produce phosgene gas, $COCl_2(g)$. A catalyst is used.

$$Cl_2(g) + CO(g) \rightleftharpoons COCl_2(g)$$

The reaction is exothermic.

View solution

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

.....

.....

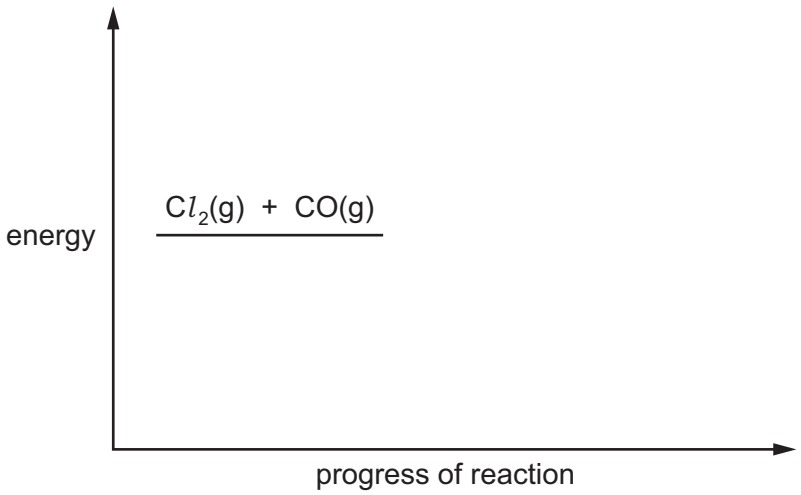
..... [3]

View solution

(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 ΔH
- an arrow representing the activation energy, labelled A.



[3]

(ii) State why a catalyst is used.

..... [1]

View solution

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

View solution

(i) the pressure is increased

.....

..... [2]

(ii) the temperature is increased.

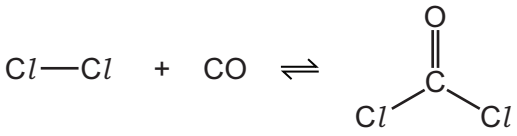
View solution

.....

..... [2]

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

View solution



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.

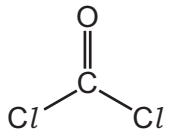
bond	bond energy in kJ / mol
C*l*–C*l*	240
C=O	745
C–C*l*	400

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

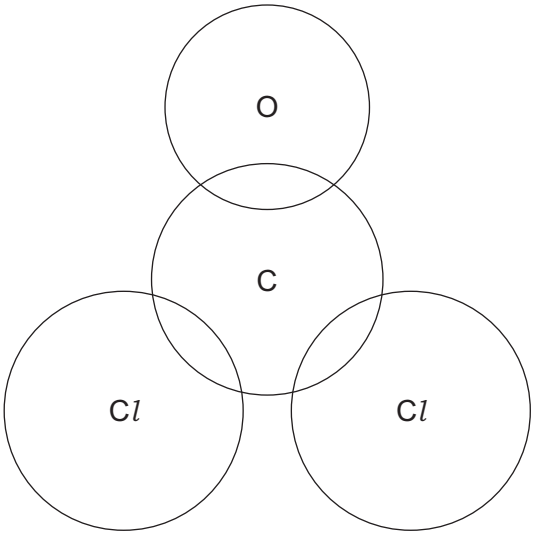
bond energy in carbon monoxide, CO = ... kJ / mol [3]

(e) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of $COCl_2$.

View solution



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.

View solution

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.

View solution

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]

View solution

(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	● steadily effervesces ● forms a colourless solution	very slowly forms an oxide layer	red
sodium	● strongly effervesces ● forms a colourless solution	slowly forms an oxide layer	
potassium	● very strongly effervesces ● forms a colourless solution	quickly forms an oxide layer	
rubidium			ruby red

(i) Add to the table:

View solution

- 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.

View solution

(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.

View solution

temperature .....

pressure .....

[2]

[Total: 22]

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

(a) Write the general formula of alcohols.

View solution

..... [1]

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

View solution

..... [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.

View solution

..... [1]

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

View solution

..... [1]

(d) Ethanol is a fuel.

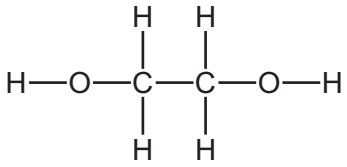
View solution

Write the chemical equation for the complete combustion of ethanol.

..... [2]

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

View solution



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 $C_6H_{10}O_4$.

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

..... [1]

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

View solution

Show all of the atoms and all of the bonds.

[2]

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

View solution

..... [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**.

View solution

..... [1]

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

View solution

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 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.).