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**CHEMISTRY**

**0620/42**

Paper 4 Theory (Extended)

**February/March 2017**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

A copy of the Periodic Table is printed on page 16.

You may lose marks if you do not show your working or if you do not use appropriate units.

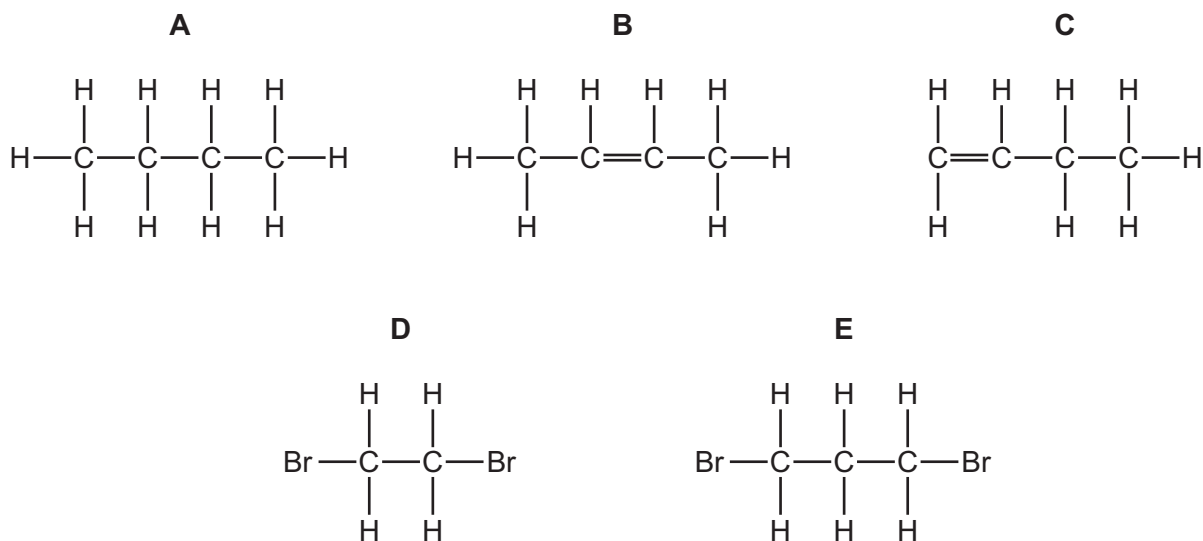
At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

This document consists of **14** printed pages and **2** blank pages.

1 (a) Five organic compounds have the following structures.



(i) Which compound is butane?

..... [1]

(ii) Which **two** compounds are structural isomers of each other?

..... [1]

(iii) Which compound can be made by reacting an alkene with bromine?

..... [1]

(iv) Which compound is a saturated hydrocarbon?

..... [1]

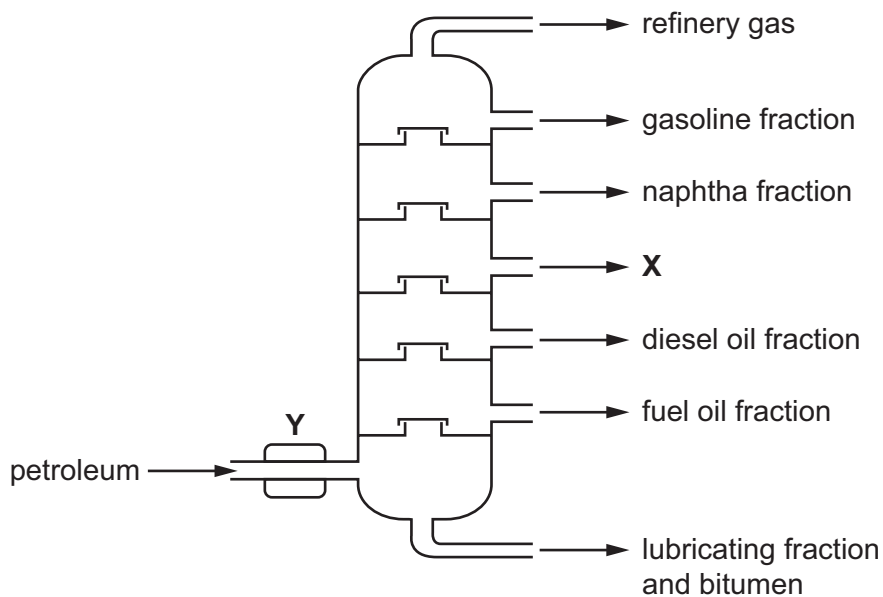
(v) Which compound has the empirical formula  $C_2H_5$ ?

..... [1]

(vi) Name the **two** products made during the complete combustion of compound **C**.

..... [1]

(b) Petroleum can be separated into useful substances using the apparatus shown.



(i) Name the fraction which is the most viscous.

..... [1]

(ii) Name the fraction with the smallest molecules.

..... [1]

(iii) Name the fraction which has the weakest attractive forces between molecules.

..... [1]

(iv) Fraction **X** is used as jet fuel.

Name fraction **X**.

..... [1]

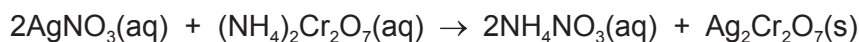
(v) What happens at point **Y** on the diagram?

..... [1]

[Total: 11]

2 Silver dichromate,  $\text{Ag}_2\text{Cr}_2\text{O}_7$ , is a red insoluble salt.

Silver dichromate can be made by reacting silver nitrate solution with ammonium dichromate solution. The chemical equation for the reaction is shown.



(a) Describe how you could obtain pure dry solid silver dichromate after mixing silver nitrate solution and ammonium dichromate solution.

.....

.....

.....

..... [3]

(b) (i) The charge on a silver ion is +1.

Deduce the charge on the dichromate ion in  $\text{Ag}_2\text{Cr}_2\text{O}_7$ .

..... [1]

(ii) Write the ionic equation for the formation of silver dichromate in this reaction. State symbols are **not** required.

..... [1]

(c) Dilute aqueous sodium hydroxide was added to the ammonium nitrate solution made in the reaction. The mixture was then warmed and damp Universal Indicator paper was held above the mixture.

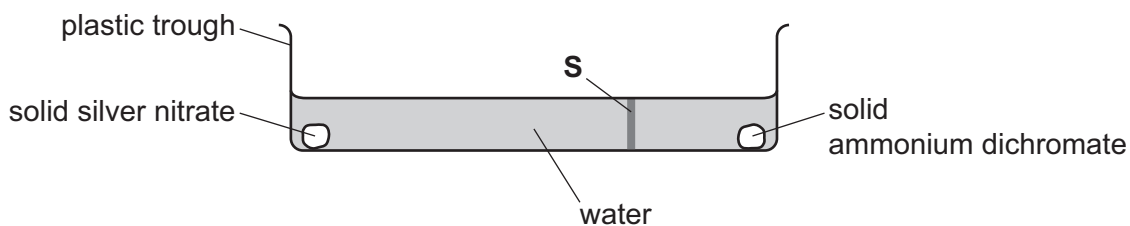
State and explain what would happen to the Universal Indicator paper.

.....

.....

..... [2]

(d) The apparatus shown was set up.



After five minutes, a red solid appeared along the line marked **S** on the diagram.

(i) Explain why a red solid appeared along the line marked **S**.

.....

.....

.....

..... [3]

(ii) The experiment was repeated at a higher temperature.

What effect, if any, would this have on the time taken for the red solid to appear? Explain your answer.

.....

..... [2]

(e) Ammonium dichromate,  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ , undergoes thermal decomposition. The products are chromium(III) oxide, nitrogen and water.

(i) What is meant by *thermal decomposition*?

.....

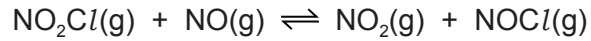
..... [2]

(ii) Write a chemical equation for the thermal decomposition of ammonium dichromate.

..... [2]

[Total: 16]

- 3 Nitryl chloride,  $\text{NO}_2\text{Cl}$ , reacts with nitric oxide,  $\text{NO}$ . The forward reaction is exothermic.



The reaction can reach equilibrium.

- (a) What is meant by the term *equilibrium* for a reversible reaction?

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

- (b) Explain why increasing the temperature increases the rate of reaction.

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

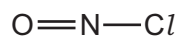
- (c) State and explain the effect, if any, of increasing the temperature on the position of equilibrium.

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

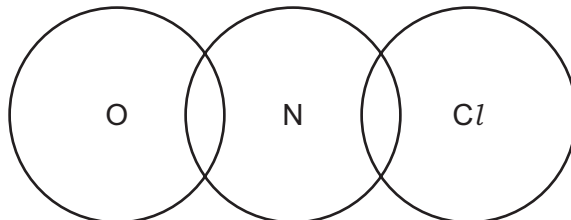
- (d) State and explain the effect, if any, of decreasing the pressure on the position of equilibrium.

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

(e) Nitrosyl chloride,  $\text{NOCl}$ , is a gas at room temperature. It has the structure shown.



(i) Complete the dot-and-cross diagram to show the arrangement of the outer shell electrons in nitrosyl chloride.



[2]

(ii) Nitrosyl chloride has a boiling point of  $-6^\circ\text{C}$ .

Explain why nitrosyl chloride has a low boiling point.

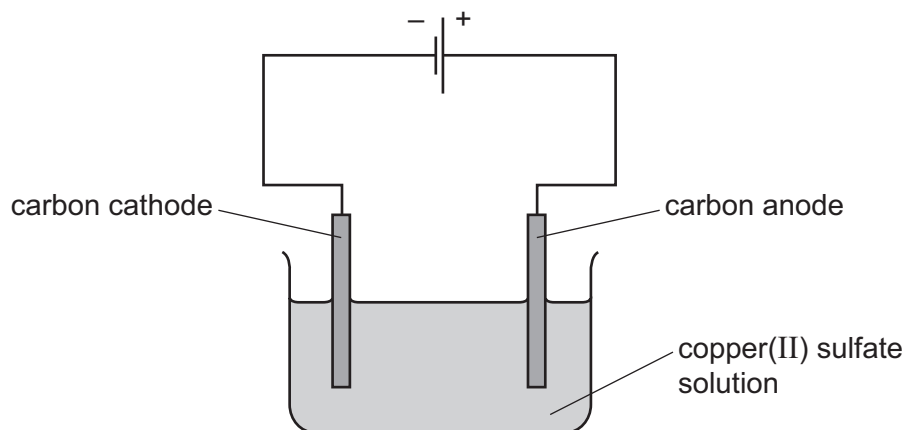
.....

.....

..... [2]

[Total: 13]

4 Copper(II) sulfate solution was electrolysed using the apparatus shown.



- (a) (i) Draw an arrow on the diagram to show the direction of movement of electrons in the wire. Label the arrow **A**. [1]
- (ii) Draw an arrow on the diagram to show the direction of movement of positive ions in the copper(II) sulfate solution. Label the arrow **B**. [1]

(b) Oxygen was formed at the anode and copper was formed at the cathode.

- (i) The ionic half-equation for the formation of oxygen is shown.



Explain why this reaction is oxidation.

..... [1]

- (ii) Write the ionic half-equation for the formation of copper at the cathode.

..... [2]

(c) The electrolysis was repeated using copper electrodes in place of carbon electrodes.

State and explain what happens to the masses of the anode and the cathode during this electrolysis.

.....

.....

.....

.....

..... [4]

[Total: 9]



5 Iron is extracted from its ore using a blast furnace.

(a) In the blast furnace, coke burns in oxygen to produce heat energy and carbon dioxide.

How is this carbon dioxide converted into carbon monoxide in the blast furnace?

..... [1]

(b) Calcium carbonate added to the blast furnace decomposes to form calcium oxide.  
Calcium oxide removes silicon(IV) oxide impurities from the iron in a neutralisation reaction.

Write a chemical equation for the reaction of calcium oxide with silicon(IV) oxide. Suggest why it is a neutralisation reaction.

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

(c) The main impurity in iron obtained from the blast furnace is carbon.

(i) Why must the high levels of carbon be lowered before the iron becomes a useful material?

..... [1]

(ii) How is the carbon removed from the iron?

.....  
..... [1]

(d) Zinc is extracted from its ore. The ore contains zinc sulfide. The zinc sulfide is roasted in air to produce zinc oxide and sulfur dioxide.

Zinc is then obtained from the zinc oxide using a blast furnace.

(i) Give the name of the ore of zinc that contains zinc sulfide.

..... [1]

(ii) Write a chemical equation for the reaction that takes place when zinc sulfide is roasted in air.

..... [1]

(iii) Suggest why the sulfur dioxide should **not** be released into the atmosphere.

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

- (iv) The temperature inside the blast furnace in which zinc is extracted is about 1000 °C.

The table gives some information about substances in the blast furnace in which zinc is extracted.

substance	melting point/°C	boiling point/°C
carbon	sublimes at 4330 °C	
silicon(IV) oxide	1610	2230
zinc	420	907

Use the data in the table to explain why the zinc obtained does **not** contain high levels of impurities such as silicon(IV) oxide and carbon.

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

[Total: 12]

- 6 Barium carbonate decomposes when heated.



- (a) A student heated a 10.0g sample of barium carbonate until it was fully decomposed.

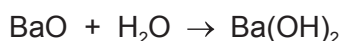
- (i) Calculate the number of moles of barium carbonate the student used.

moles of barium carbonate = ..... mol [2]

- (ii) Calculate the volume of carbon dioxide gas produced at room temperature and pressure. Give your answer in  $\text{dm}^3$ .

volume of carbon dioxide = .....  $\text{dm}^3$  [1]

- (b) The student added 2.00g of the barium oxide produced to water.

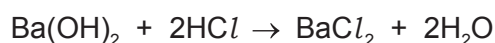


Calculate the mass of barium hydroxide that can be made from 2.00g of barium oxide. The  $M_r$  of  $\text{Ba}(\text{OH})_2$  is 171.

mass of barium hydroxide = ..... g [1]

- (c) A 1.50g sample of barium hydroxide was dissolved in water. The total volume of the solution was  $100\text{ cm}^3$ .

A  $25.0\text{ cm}^3$  portion of the barium hydroxide solution was titrated against hydrochloric acid. The volume of hydrochloric acid required was  $18.75\text{ cm}^3$ .



- (i) Calculate how many moles of barium hydroxide were in the  $25.0\text{ cm}^3$  portion used in the titration.

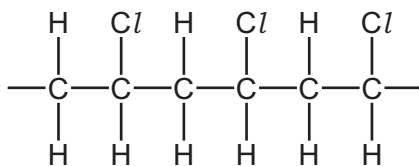
moles of barium hydroxide = ..... mol [1]

- (ii) Calculate the concentration of the hydrochloric acid used.

concentration of hydrochloric acid = .....  $\text{mol}/\text{dm}^3$  [2]

[Total: 7]

- 7 (a) The diagram shows part of the structure of an addition polymer.



- (i) Draw a circle around **one** repeat unit of the polymer. [1]
- (ii) Draw the structure of the monomer from which this addition polymer is made. [1]

- (iii) Aqueous bromine is added to both the polymer and the monomer.

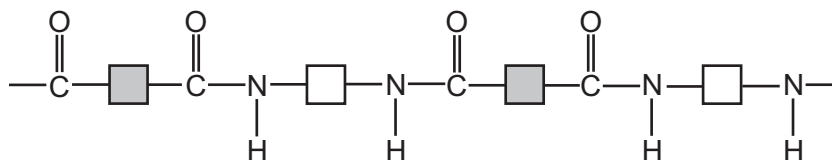
Describe what would be seen in each case.

with the polymer .....

with the monomer .....

[2]

- (b) The diagram shows part of the structure of a condensation polymer.



- (i) What type of condensation polymer is this? [1]
- .....
- (ii) On the diagram, draw a circle around **one** repeat unit of the polymer. [1]
- (iii) Draw the structures of the **two** monomers from which the condensation polymer is made. [2]

(c) Hydrolysis of a polymer gave a compound with the following composition by mass: C, 34.61%; H, 3.85%; O, 61.54%.

(i) Calculate the empirical formula of the compound.

empirical formula = ..... [3]

(ii) What additional information is needed to calculate the molecular formula of the compound?

.....

..... [1]

[Total: 12]



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## The Periodic Table of Elements

Group																																					
I	II											III	IV	V	VI	VII	VIII																				
		<b>Key</b>										1 <b>H</b> hydrogen 1								2 <b>He</b> helium 4																	
		atomic number atomic symbol name relative atomic mass										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															
		3 <b>Li</b> lithium 7		4 <b>Be</b> beryllium 9												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											
		11 <b>Na</b> sodium 23		12 <b>Mg</b> magnesium 24												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											
		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		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	
		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		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 –	
		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		114 <b>Fl</b> flerovium –		116 <b>Lv</b> livermorium –									
		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 –													

lanthanoids	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
actinoids	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.).