MODEL ANSWERS

Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel International GCSE (9–1)

Centre Number | | | | | |

Candidate Number | | | | |

Thursday 14 January 2021

Morning (Time: 1 hour 15 minutes) | Paper Reference **4CH1/2CR**

Chemistry

Unit: 4CH1

Paper: 2CR

You must have:
Calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- Show all the steps in any calculations and state the units.
- Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Information

- The total mark for this paper is 70.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Write your answers neatly and in good English.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 6 7 0 8 2 A 0 1 2 4

Pearson

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
							1 H hydrogen 1										4 He helium 2
7 Li lithium 3	9 Be beryllium 4											11 B boron 5	12 C carbon 6	14 N nitrogen 7	16 O oxygen 8	19 F fluorine 9	20 Ne neon 10
23 Na sodium 11	24 Mg magnesium 12											27 Al aluminium 13	28 Si silicon 14	31 P phosphorus 15	32 S sulfur 16	35.5 Cl chlorine 17	40 Ar argon 18
39 K potassium 19	40 Ca calcium 20	45 Sc scandium 21	48 Ti titanium 22	51 V vanadium 23	52 Cr chromium 24	55 Mn manganese 25	56 Fe iron 26	59 Co cobalt 27	59 Ni nickel 28	63.5 Cu copper 29	65 Zn zinc 30	70 Ga gallium 31	73 Ge germanium 32	75 As arsenic 33	79 Se selenium 34	80 Br bromine 35	84 Kr krypton 36
85 Rb rubidium 37	88 Sr strontium 38	89 Y yttrium 39	91 Zr zirconium 40	93 Nb niobium 41	96 Mo molybdenum 42	[98] Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La* lanthanum 57	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111	Elements with atomic numbers 112–116 have been reported but not fully authenticated						

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

**** The lanthanoids (atomic numbers 58–71) and the actinoids (atomic numbers 90–103) have been omitted.***

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

Answer ALL questions.

1 Substances can exist as solids, liquids or gases.

(a) (i) Give the change of state that occurs when a substance melts.

(1)

From Solid to Liquid.

(ii) Complete the word equation for the sublimation of iodine.

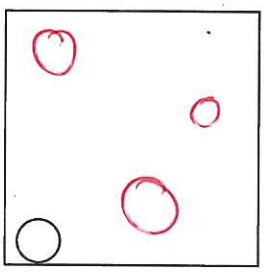
iodine (s) → iodine (.....g.....)

(1)

(b) The circle in the diagram represents a particle.

Complete the diagram to show the arrangement of particles in a gas.

(1)



(c) The table lists some statements about particles.

Place ticks (✓) in boxes to show which two statements are correct for water particles.

(2)

Statement	Tick
the particles only vibrate	
the particles do not move	
the particles have no gaps between them	
the particles move randomly	✓
the particles have more energy than in ice	✓
the particles have a regular arrangement	

(Total for Question 1 = 5 marks)

2 This question is about elements in Group 7 and their compounds.

The table gives information about some of these elements.

Element	Symbol	Melting point in °C	Boiling point in °C	Colour at room temperature (20 °C)
fluorine	F	−220	−188	
chlorine	Cl	−101	−35	pale green
bromine	Br	−7	59	red-brown
iodine	I	114	184	grey

(a) (i) Predict the colour of fluorine at room temperature.

(1)

pale yellow

(ii) How many of the elements in the table are liquids at room temperature (20 °C)?

(1)

- ☐ **A** 0
- ☒ **B** 1
- ☐ **C** 2
- ☐ **D** 3

(iii) The element astatine is below iodine in Group 7.

Predict the formula of a molecule of astatine.

(1)

At_2

(b) Sea water contains bromide ions.

Bromine can be obtained by bubbling chlorine through a sample of sea water.

The ionic equation for the reaction is

$$Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$$

(i) Explain which species acts as an oxidising agent in this reaction.

(2)

Cl_2 is the oxidising agent because Chlorine gains electrons so is reduced.

(ii) The reaction occurs because chlorine is more reactive than bromine.

Bromine is below chlorine in Group 7.

Explain the decrease in reactivity from chlorine to bromine.

(3)

Bromine and Chlorine react by forming 1- ions
The bromine atom is larger than a chlorine atom so the bromine atom has a weaker attraction from the nucleus on the outer shell electrons so bromine has a ~~lesser~~ lower tendency to gain an electron to form the negative ion, making it less reactive.

(c) Elements in Group 7 react with elements in Group 1 to form ionic compounds.

Which pair of ions both have the electronic configuration 2.8.8?

(1)

- ☐ **A** Li^+ and Cl^-
- ☐ **B** K^+ and F^-
- ☐ **C** Li^+ and F^-
- ☒ **D** K^+ and Cl^-

(Total for Question 2 = 9 marks)

3 (a) Explain why metals conduct electricity but covalent compounds do not conduct electricity.

(4)

Metals Conduct delocalised electrons which can move, so it can Conduct electricity.

Covalent Molecules have no overall charge and the electrons cannot move so they don't Conduct electricity.

(b) Hydrogen chloride, HCl, is a covalent substance.

When hydrogen chloride is added to water, a solution of dilute hydrochloric acid is formed.

This solution does conduct electricity.

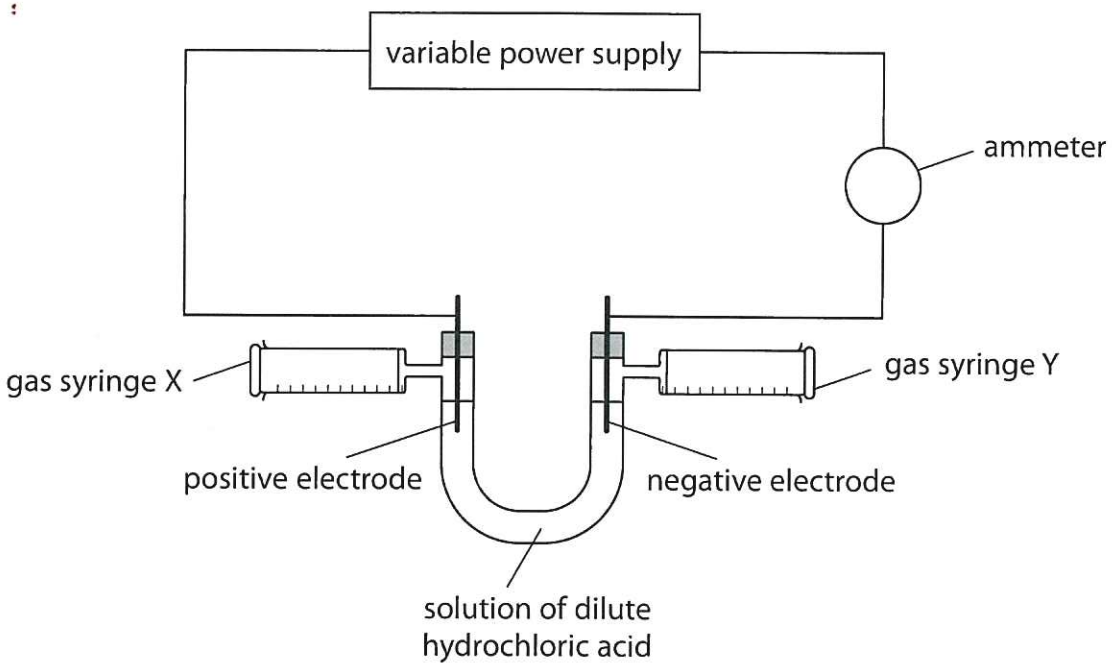
Name the type of particle in the solution of the dilute hydrochloric acid that allows it to conduct electricity.

(1)

Ions

(c) The teacher uses this apparatus to investigate the electrolysis of a solution of dilute hydrochloric acid.

The ammeter measures the current.



The teacher wants to find out if there is a relationship between current and volume of gas collected at each electrode.

She adjusts the power supply until the current is 0.1 amp.

After 5 minutes she records the volume of gas collected in syringe X and syringe Y.

The teacher repeats the experiment several times, using a different current each time.

The table gives the teacher's results for syringe Y.

Current in amp	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Volume of gas in cm^3	8	15	22	25	37	44	52	60

(i) Plot the results for syringe Y.

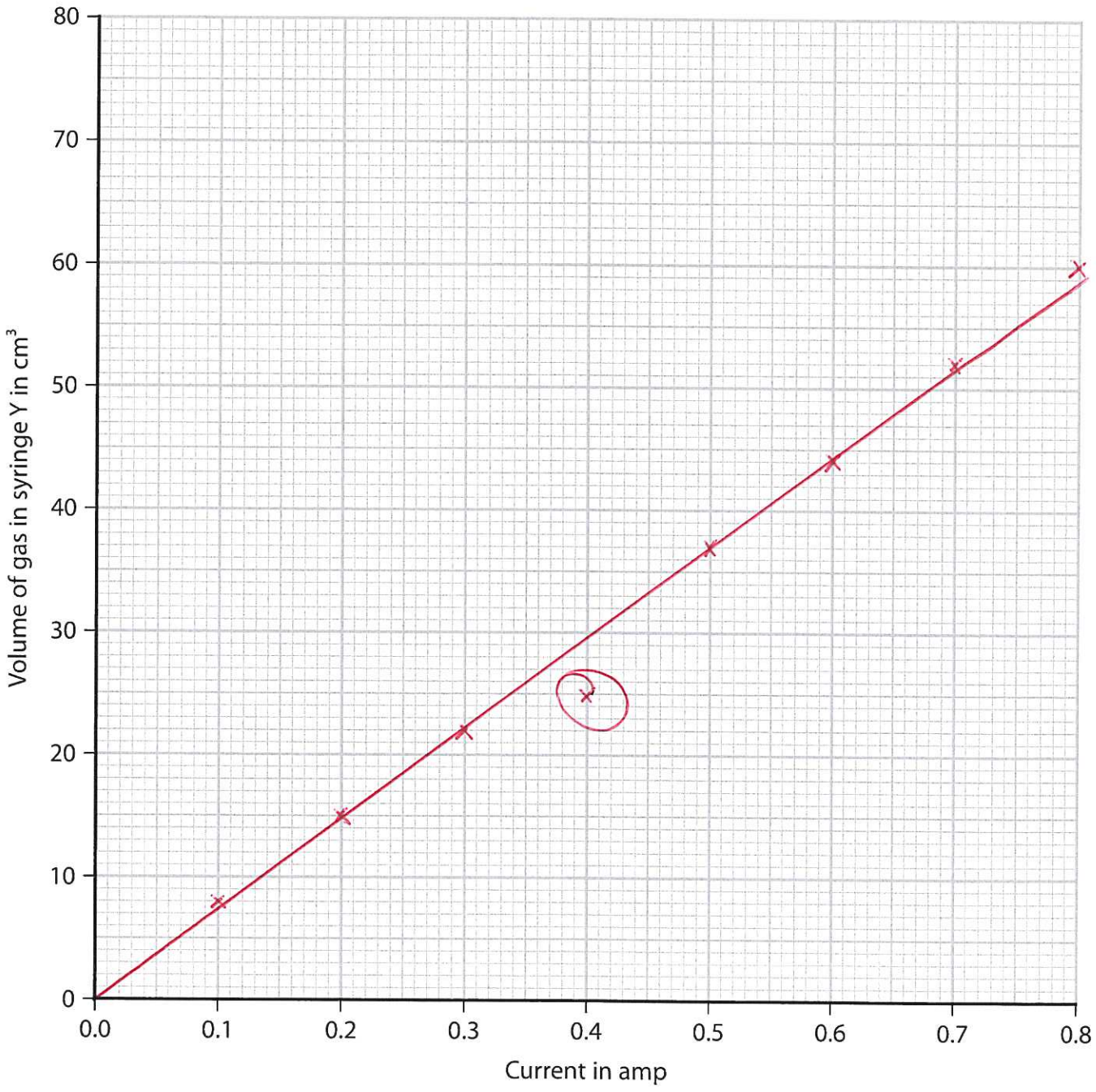
(1)

(ii) Draw a circle around the anomalous result.

(1)

(iii) Draw a line of best fit.

(1)



(iv) Explain a possible cause of the anomalous result, other than misreading the apparatus.

(2)

The Volume reading is less than expected as the Current was actually less than 0.4A or some gas escaped.

(v) Deduce the relationship between current and volume of gas collected in syringe Y.

(1)

Greater the Current, the greater the Volume of gas.

(d) The ionic half-equation for the reaction that produces the gas in syringe X is

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

The ionic half-equation for the reaction that produces the gas in syringe Y is

$$2H^+ + 2e^- \rightarrow H_2$$

(i) Suggest how these ionic half-equations show that the volume of chlorine collected in syringe X should be the same as the volume of hydrogen collected in syringe Y.

(1)

the transfer of two moles of electrons produces one mole of $Cl_{2(g)}$ and one mole of $H_{2(g)}$

(ii) Suggest why the volume of chlorine collected in syringe X is always less than the volume of hydrogen collected in syringe Y.

(1)

Chlorine dissolves into the acid.

(Total for Question 3 = 13 marks)

4 This question is about alcohols, carboxylic acids and esters.

(a) The table gives information about some alcohols.

Alcohol	Structural formula	Relative formula mass
methanol	CH_3OH	32
ethanol	C_2H_5OH	46
Butanol	C_4H_9OH	74

Complete the table by giving the missing information.

(2)

(b) Ethanol can be oxidised to ethanoic acid by heating with potassium dichromate(VI) and another reagent.

(i) Name the other reagent.

(1)

Sulphuric acid

(ii) State the colour change that occurs during this reaction.

(1)

from Orange to green

(c) Alcohols react with carboxylic acids to form esters.

(i) Name the ester that forms when ethanol reacts with ethanoic acid.

(1)

ethyl ethanoate.

(ii) Complete the equation for the reaction between methanol and ethanoic acid.

(2)

CH_3OH + CH_3COOH → CH_3COOCH_3 + H_2O

(Total for Question 4 = 7 marks)

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5 Hydrogen peroxide solution decomposes slowly at room temperature to form water and oxygen.

The equation for the reaction is

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

(a) A catalyst increases the rate of this reaction.

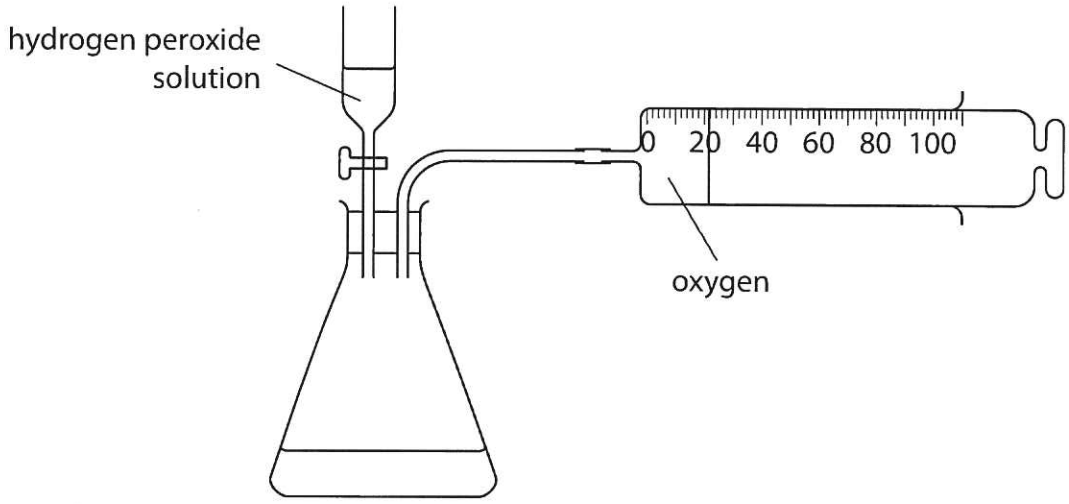
State one other property of a catalyst.

(1)

A Catalyst is Chemically unchanged at the end of the reaction.

(b) A student has samples of three solids, X, Y and Z.

The student uses this apparatus to find out which solids act as catalysts in the decomposition of hydrogen peroxide solution.



Describe the method that the student should use to find out which solids act as catalysts.

(6)

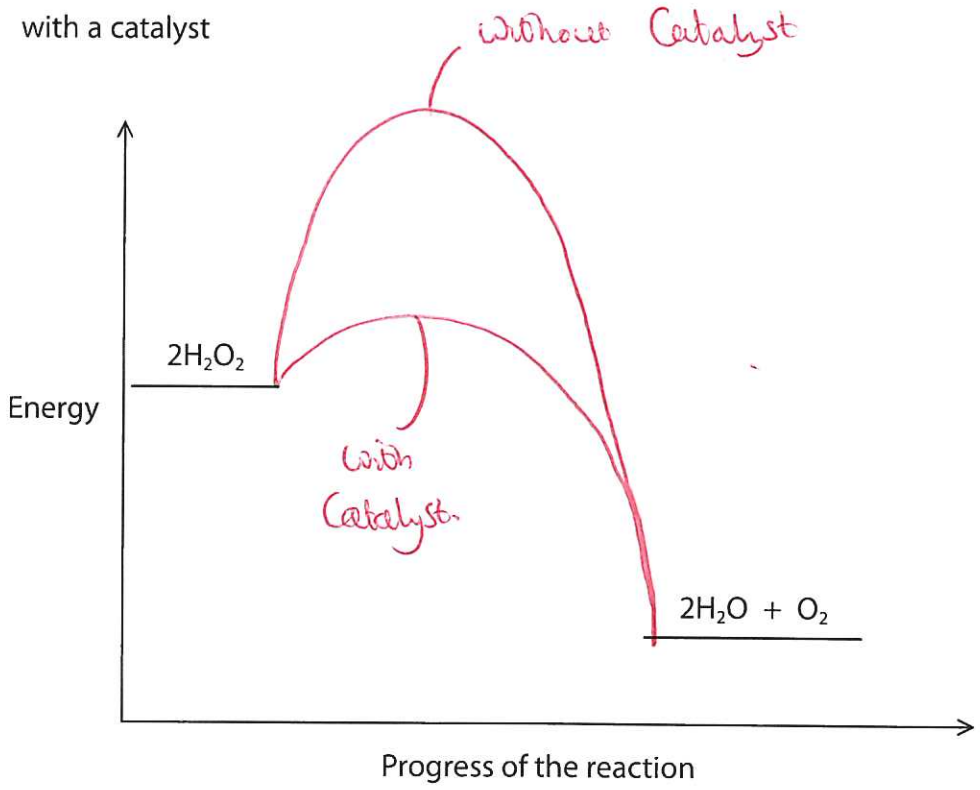
Do the experiment first using only H_2O_2 and no X, Y or Z.
Ensure a known volume of H_2O_2 solution is used, measuring the time taken for a certain volume of gas to be collected.
Repeat this using the same volume of H_2O_2 solution but with a known mass of solid X before repeating with Y, then Z.
After the reaction, filter and dry the solid from the reaction mixture, checking to see if the mass of the solid is unchanged.
If X, Y, or Z may be a catalyst, the time taken for a fixed volume of gas to be produced must be reduced when the catalyst is used.

(c) The decomposition of hydrogen peroxide solution is exothermic.

On the diagram, draw and label the reaction profiles for the reaction

- without a catalyst
- with a catalyst

(2)



(d) The equation for the reaction can be shown using displayed formulae.

$$2\,H{-}O{-}O{-}H \rightarrow 2\,H{-}O{-}H + O{=}O \qquad \Delta H = -204\,kJ$$

The table gives the bond energies for two of the bonds.

Bond	Bond energy in kJ/mol
H—O	463
O—O	146

(i) Use this information to calculate the total amount of energy needed to break all the bonds in two moles of H_2O_2

(1)

Energy = 4(463) + 2(146)

= 2144 KJ

energy needed = 2144 kJ

(ii) Use this information to calculate the total amount of energy released when all the bonds in two moles of H_2O are formed.

(1)

Energy = 4(463) = 1852 KJ

energy released = 1852 kJ

(iii) Use the value of ΔH and your answers for (i) and (ii) to calculate the bond energy, in kJ/mol, for the O=O bond.

(2)

ΔH = Breaking − making

−204 = 2144 − (1852 + x)

1852 + x = 2144 + 204

x = 2144 + 204 − 1852

x = 496

bond energy = 496 kJ/mol

(Total for Question 5 = 13 marks)

6 A student does a titration using dilute sulfuric acid to find the concentration of a solution of potassium hydroxide.

The student adds 25.0 cm^3 of the potassium hydroxide solution to a conical flask. He then adds a few drops of methyl orange indicator.

The student does the titration four times.

(a) (i) Name the piece of apparatus the student should use to add the potassium hydroxide solution.

(1)

Pipette

(ii) What is the colour of methyl orange in an alkaline solution?

(1)

- ☐ **A** blue
- ☐ **B** orange
- ☐ **C** red
- ☒ **D** yellow

(b) The table shows the student's results.

titration	1	2	3	4
volume of acid added in cm^3	20.65	20.60	20.90	20.55
concordant results	✓	✓		✓

Concordant results are those within 0.20 cm^3 of each other.

(i) Place ticks (✓) in the table to show which results are concordant.

(1)

(ii) Use the concordant results to calculate the mean (average) volume of acid added.

(2)

$$\text{Mean} = \frac{20.65 + 20.60 + 20.55}{3}$$

$$= 20.60$$

mean volume = 20.60 cm^3

(c) This table shows the student's results for another titration.

volume of potassium hydroxide solution used in cm^3	25.0
concentration of potassium hydroxide solution in mol/dm^3	0.0370
mean volume of sulfuric acid added in cm^3	21.20

The equation for the reaction is

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

(i) Calculate the amount, in moles, of KOH in 25.0 cm^3 of the potassium hydroxide solution.

(2)

$n(KOH) = Conc \times vol$

$= 0.0370 \times 25 \times 10^{-3}$

$= 9.25 \times 10^{-4}$

amount of KOH = 9.25×10^{-4} mol

(ii) Calculate the amount, in moles, of H_2SO_4 in 21.20 cm^3 of sulfuric acid.

(1)

$n(H_2SO_4) = \frac{n(KOH)}{2} = \frac{9.25 \times 10^{-4}}{2}$

amount of H_2SO_4 = 4.625×10^{-4} mol

(iii) Calculate the concentration, in mol/dm^3, of the sulfuric acid.

(2)

$Conc = \frac{mol}{Vol} = \frac{4.625 \times 10^{-4}}{21.2 \times 10^{-3}}$

$= 0.0218$

concentration of sulfuric acid = 0.0218 mol/dm^3

(3 S.g.f.)

(Total for Question 6 = 10 marks)

7 A sample of a gaseous hydrocarbon, X, has a volume of 600 cm^3 at room temperature and pressure (rtp).

(a) Calculate the amount, in moles, of hydrocarbon X in the sample.

[molar volume of a gas = 24 000 cm^3 at rtp]

(2)

$mol = \frac{600}{24000} = 0.025\ mol$

amount of hydrocarbon X = 0.025 mol

(b) The mass of the sample of hydrocarbon X is 1.45 g.

Show that the relative molecular mass (M_r) of X is 58

(2)

$mass = mr \times mol$

$mr = \frac{mass}{mol} = \frac{1.45}{0.025} = 58$

M_r = 58

(c) Hydrocarbon X is an alkane.

Show that the molecular formula of X is C_4H_{10}

(1)

X: C_nH_{2n+2}

$58 = 12n + (2n+2)$

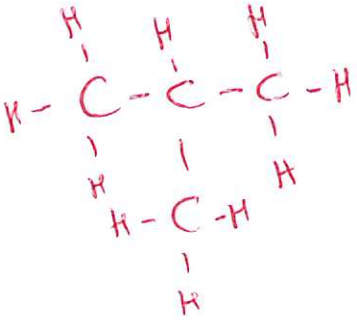
$58 = 12n + 2n + 2$

$56 = 14n$

$n = \frac{56}{14} = 4 \therefore X = C_4H_{2(4)+2} = C_4H_{10}$

(d) Give the displayed formula of the branched-chain isomer of hydrocarbon X.

(1)



(Total for Question 7 = 6 marks)

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8 This question is about ammonia gas, NH_3

(a) Ammonia can be prepared in a laboratory from the reaction between ammonium chloride, NH_4Cl, and sodium hydroxide. The other products of the reaction are sodium chloride and water.

(i) Give a chemical equation for this reaction.

(1)

$NH_4Cl + NaOH \rightarrow NaCl + NH_3 + H_2O$

(ii) Give a test for ammonia gas.

(2)

Ammonia gas turns damp red litmus paper blue.

(b) In industry, ammonia is produced from nitrogen and hydrogen.

The equation for this reaction is

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

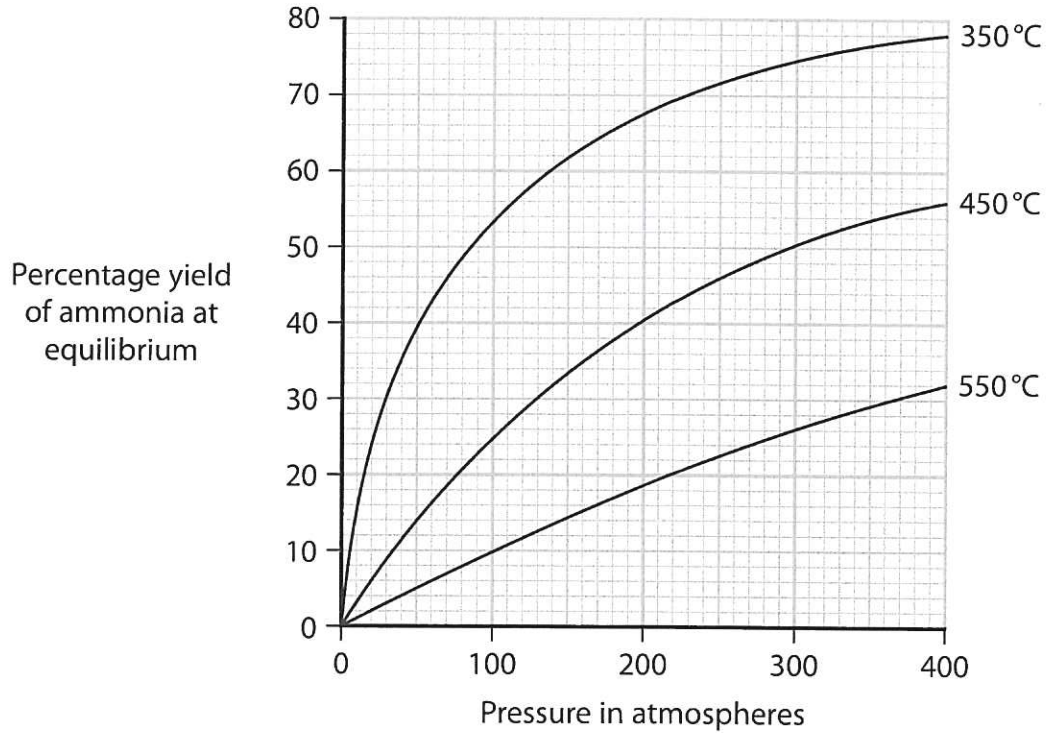
In a sealed container, the reaction can reach a position of dynamic equilibrium.

Explain the meaning of the term **dynamic equilibrium**.

(2)

When the rate of the forwards reaction is equal to that of the reverse reaction and the concentrations of reactants and products don't change.

(c) The graph shows the percentage yield of ammonia at equilibrium for different temperatures and pressures.



Using the graph, explain if the forward reaction is exothermic or endothermic.

(2)

Increasing temperature decreases the yield of ammonia. So the forward reaction is exothermic.

(Total for Question 8 = 7 marks)

(TOTAL FOR PAPER = 70 MARKS)

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