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CENTRE NUMBER

CHEMISTRY

Paper 2 Structured Questions

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INDEX

NUMBER

Candidates answer on the Question Paper. Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name in the spaces provided at the top of this page.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 ON ANY BARCODES.

Section A Answer **all** the questions.

Section B Answer one question.

The use of an approved scientific calculator is expected, where appropriate.

A Data Booklet is provided.

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

This document consists of 21 printed pages and 3 blank pages.



Singapore Examinations and Assessment Board

Cambridge Assessment



Section A

Answer **all** the questions in this section in the spaces provided.

1 (a) Write an equation to represent the second ionisation energy of lead.

```
\mathbf{Pb}^{+}(\mathbf{g}) \rightarrow \mathbf{Pb}^{2+}(\mathbf{g}) + \mathbf{e}^{-} 
[1]
```

(b) Lead(IV) carbonate, $Pb(CO_3)_2$, decomposes on heating.

A student believes that when $Pb(CO_3)_2$ is heated strongly either lead(II) oxide, PbO, or lead(IV) oxide, PbO₂, is made as the final solid product.

Equation 1 represents the reaction if PbO is the final product.

Equation 2 represents the reaction if PbO_2 is the final product.

equation 1 $2Pb(CO_3)_2(s) \rightarrow 2PbO(s) + 4CO_2(g) + O_2(g)$ equation 2 $Pb(CO_3)_2(s) \rightarrow PbO_2(s) + 2CO_2(g)$

A student heats 14.43g of lead(IV) carbonate until it is fully decomposed. 2600 cm³ of gas measured at room temperature and pressure is collected.

Determine, using the data provided, whether lead(II) oxide or lead(IV) oxide is the final solid product obtained by the student. Show your working and explain your choice.

$$n_{\text{Pb}(\text{CO}_3)_2} = \frac{14.43}{207.2 + 2(12.0 + 3 \times 16.0)}$$
$$= \frac{14.43}{327.2}$$
$$= 0.04410 \text{ mol}$$
$$n_{\text{gas}} = \frac{2600}{24000} = 0.1083 \text{ mol}$$

 $n_{Pb(CO_3)_2}$: $n_{gas} = 0.04410: 0.1083 \approx 1:2.5 = 2:5$

The molar ratio of $Pb(CO_3)_2$ to the gases follows the stoichiometry of equation 1. Hence **lead(II) oxide** is the final solid produced obtained.

[3]

[Total: 4]





Ethanol is manufactured by reacting ethene with steam as shown in the equation.

 $C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$ $\Delta H = -45 \text{ kJ mol}^{-1}$

(a) Suggest and explain three changes which will increase the percentage yield of ethanol in the reaction.

Firstly, employ a lower reaction temperature. Equilibrium will shift to the right in attempt to counter this change by releasing heat energy (exothermic direction), thereby increasing the percentage yield. Secondly, increase the partial pressure of ethene in the reaction chamber. Equilibrium will shift to the right in attempt to remove the added ethene, while at the same time reacting with more steam, increasing the percentage yield. Lastly, decrease the volume of the reaction chamber. Equilibrium will shift to the right in attempt to the right with fewer gaseous particles in attempt to decrease the total pressure, increasing the percentage yield.

(b) State and explain the effect that each of the three changes identified in (a) has on the rate of the reaction.

Firstly, when reaction temperature is lowered, fewer reactant molecules have sufficient energy to overcome the activation energy upon collision. In addition, the molecules move more slowly, lowering the number of collisions. Hence number of effective collision decreases, lowering the rate of reaction. The second and third change, increases the partial pressure of ethene and increases the total pressure, respectively. Both lead to an increase in the number of collisions between the molecules, hence increasing the number of effective collision and thus increasing the rate of reaction. [3]

(c) Write the expression for K_c for this reaction and give its units.

$$K_{c} = \frac{\left[\mathsf{C}_{2}\mathsf{H}_{5}\mathsf{O}\mathsf{H}\right]}{\left[\mathsf{C}_{2}\mathsf{H}_{4}\right]\left[\mathsf{H}_{2}\mathsf{O}\right]}$$

(d) State and explain the effect on K_c of increasing the temperature of the reaction mixture.
 Since the forward reaction is exothermic, increasing temperature will cause the position of equilibrium to shift left, to remove heat energy in attempt to lower the temperature.
 [C₂H₅OH] decreases while [C₂H₄] and [H₂O] increases at equilibrium, hence lowering K_c[2]

[Total: 10] [Turn over



3 Potassium fluoride is a white crystalline solid with a melting point of 860 °C. It dissolves in water to form a solution which conducts electricity.

Naphthalene, $C_{10}H_8$, is a white crystalline solid with a melting point of 80 °C. It does not conduct electricity in the solid state nor in the liquid state. It is insoluble in water.

Silicon dioxide is a white crystalline solid with a melting point of 1715°C. It does not conduct electricity in the solid state nor in the liquid state. It is insoluble in water.

Iron is a grey solid which melts at 1535 °C. Iron conducts electricity in both the solid and liquid states.

Name the type of structure and describe the bonding in the solids potassium fluoride, naphthalene, silicon dioxide and iron. You may wish to include diagrams to illustrate your answer. [8]

Solid potassium fluoride has a giant ionic lattice structure, comprising of oppositely charged K⁺

and CL ions, held together in a regular lattice by electrostatic attraction.

Solid napthalene has a simple covalent (lattice) structure, comprising of discrete non-polar

napthalene molecules held together in a regular lattice by instantaneous dipole-induced dipole

attractions.

Solid silicon dioxide has a giant covalent (lattice) structure, comprising of a regular covalent

network of tetrahedrally bonded silicon and linearly bonded oxygen atoms held together by

strong Si–O covalent bonds as shown below:

Si O Si

Si O / Si

Solid iron has a giant metallic (lattice) structure, comprising of an array of positively charged iron ions, held together in a regular lattice, by electrostatic attraction with a sea of delocalised

electrons.







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***************************************	***************************************	 *******************************

[Total: 8]





4 Aspartame is used as an artificial sweetener.



(a) Deduce the molecular formula of aspartame.

C₁₄H₁₈N₂O₅ [1]

(b) Draw a circle around each functional group present in the aspartame molecule in Fig. 4.1. Do **not** include the benzene ring.

Label each circle with the name of the functional group it contains. [4]

(c) Sodium metal reacts with the carboxylic acid functional group in aspartame in the same way as sodium metal does with a strong acid.

Write an equation for the reaction of this functional group with sodium. Use R to represent the rest of the carboxylic acid molecule.

$2RCO_2H + 2Na \rightarrow 2RCO_2Na^+ + H_2$	٢1	1
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- (d) Aspartame can be hydrolysed.
 - (i) Draw lines on Fig. 4.2 through all the bonds which are broken during the complete hydrolysis of aspartame.



Fig. 4.2



[1]



(ii) Draw the structure of the hydrolysis product with the smallest $M_{\rm r}$.

7

CH₃OH

[1]

[Total: 8]





5 Disposable ('one-use') coffee cups are proving to be a problem in the environment.

The outer layer of most of these cups is made from paper, which is biodegradable (can be broken down by the environment). The inside of the cups are often lined with low-density poly(ethene). The poly(ethene) layer makes the cup waterproof and so is able to hold a hot drink. Recycling this type of disposable coffee cup requires the use of a specialised recycling method.

PLA is a biodegradable polymer. It is a thermoplastic often made from sugar cane or corn starch. It has the structure shown.



It is possible to develop disposable coffee cups made from PLA.

(a) (i) Suggest how the properties of LDPE make it more suitable than HDPE for coating the cups.

LDPE has lower crystallinity and hence is softer and more flexibility compared to

HDPE, allowing greater ease for coating the curved interior of a coffee cup. [1]

(ii) Describe how the structure of LDPE gives it the properties described in (a)(i).

LDPE has significant branching in its structure, weakening the instantaneous dipole-

induced dipole attracts between the polymer strands and hence lowering crystallinity.[1]

(iii) Suggest why a specialised method is needed to recycle these cups.

The LPDE coating on these cups are **non-biodegrable**. Hence, a specialised method

is needed to first remove the LDPE coating before the paper cups can be recycled. [1]

(b) (i) Explain the meaning of the term *thermoplastic*.

Thermoplastic is a plastic polymer material that becomes pliable or moldable at a

- certain elevated temperature and solidifies upon cooling.
- (ii) Name the functional group present in the thermoplastic polymer PLA and classify the type of polymerisation used to make it.

functional group <u>ester</u> classification of polymerisation <u>condensation polymerisation</u>

[1]



(iii) Use the table of characteristic infra-red absorption frequencies in the *Data Booklet* to answer this question.

PLA absorbs ultraviolet radiation which causes it to degrade.

The part of the PLA molecule responsible for absorbing the ultraviolet radiation also absorbs infra-red radiation in the region 1710-1750 cm⁻¹.

State which bond in the PLA molecule is responsible for it being degradable.

C=O bond [1]

[Total: 6]





6 Carbon can exist in a number of different forms including graphite, diamond and graphene.

Graphene is a nanomaterial. It is a 2-dimensional layer of carbon atoms which is one atom thick. The C-C bonds are very strong. Graphene is a good conductor of electricity.

In the nanomaterial fluorographene, the fourth electron of each carbon atom is bonded to a fluorine atom. The C-F bond is very strong. Fluorographene has high thermal stability and excellent non-stick properties.

Whilst producing graphene, scientists have made sheets of graphene oxide. Graphene oxide sheets can be made with holes between 0.8 and 1.6 nm in size. It is hoped that these graphene oxide sheets with holes could be developed into filters for the desalination of water (removal of the hydrated ions of salt shown in Fig. 6.1). Such a filtration process would be much faster and cheaper than those used today.



sodium ions and chloride ions hydrated by water molecules

Fig. 6.1

(a) Explain the difference between a nanoparticle and a nanomaterial.

Nanoparticles are discrete particles with all three dimension in the size range between 1 to 100

nm, while nanomaterials have structured components with at least one dimension in this range. [1]

(b) (i) Draw a diagram to illustrate the structure of graphene.



(ii)	Explain why graphene is a good electrical conductor.	[1]
	The lone electron in the unhybridised p orbital of each carbon atom is delocalise	d
	over the whole lattice structure.	[2]

141



(c) (i) Suggest a value for the C-C-F bond angle in fluorographene.

Explain your answer.

109.5°. Since each carbon is bonded to three other carbon atoms and one fluorine

atom, it is sp³-hybridised with a tetrahedral arrangement.

......[2]

- (ii) Deduce the empirical formula for fluorographene.
 - <u>CF</u> [1]
- (iii) Suggest why fluorographene could be suitable to use as a coating for self-cleaning windows.

Due to the **excellent non-stick property** of fluorographene, it could be suitable to use

as a coating for self-cleaning windows wherein dirt will not stick on the coating. [1]

(iv) Suggest a property of fluorographene not mentioned in the information given on page 10. State the feature of the fluorographene molecule which led you to choose this property.

Due to the absence of mobile particles in fluorographene, fluorographene should be a

(d) Suggest how graphene oxide sheets are only big enough for small water molecules to pass through, while hydrated Na⁺(aq) and C*t*⁻(aq) ions are too large to pass through the

holes and retained, thus removing them from water (desalinate). [1]

[Total: 10]





12

(a) Define the term relative atomic mass of an element.

The relative atomic mass of an element is the average mass of one atom of the element,

compared to 1/12 the mass of a carbon-12 atom. [1]

(b) A sample of pure sulfur which contains only ³²S and ³⁴S has a relative atomic mass of 32.11.

Calculate the percentage abundances of both ³²S and ³⁴S in this sample of sulfur.

Let the % abundance of ${}^{32}S$ be *x* %. % abundance of ${}^{34}S = (100 - x)\%$

 $\frac{x}{100} \times 32 + \frac{100 - x}{100} \times 34 = 32.11$ 3400 - 2x = 3211x = 94.5

% abundance of ${}^{32}S$ is <u>94.5%</u>, % abundance of ${}^{34}S$ is <u>5.50%</u>.

[2]

(c) Sulfur(IV) oxide is a common pollutant in the air. It is formed when sulfur-containing fuels are burned. Sulfur(IV) oxide can be oxidised to sulfur(VI) oxide which reacts with water to form acid rain.

Nitrogen(IV) oxide is also a common pollutant in the air. It is formed in internal combustion engines when nitrogen in air reacts with oxygen in air at high temperature. It is more stable than nitrogen(II) oxide. Nitrogen(II) oxide oxidises to nitrogen(IV) oxide in air.

When nitrogen(IV) oxide reacts with sulfur(IV) oxide, it is reduced to nitrogen(II) oxide. During the reaction 42 kJmol^{-1} of energy is released.

(i) Write an equation for the reaction of sulfur(IV) oxide with nitrogen(IV) oxide.

 $SO_2 + NO_2 \rightarrow SO_3 + NO$ [1]

(ii) Write an equation to show what happens to the nitrogen(II) oxide formed in (c)(i).

$2NO + O_2 \rightarrow 2NO_2$	[1]
	ניז



(iii) Show how the equations in (c)(i) and (c)(ii) can be used to write the overall equation for the oxidation of sulfur(IV) oxide.



(iv) Draw an energy profile diagram for the reaction of sulfur(IV) oxide with nitrogen(IV) oxide. Label the activation energy E_a , and the enthalpy of reaction ΔH .



- (d) Chlorine dioxide, ClO₂, contains two double bonds.
 - (i) State the total number of outer shell electrons in one molecule of ClO_2 and explain why this is an unusual number.

19 outer shell electrons. This is an unusual number as the number is **odd**, meaning

that there is an **unpaired electron** in the outer shell. [1]

(ii) ClO_2 forms the negative ion ClO_2^- .

Draw a 'dot-and-cross' diagram for the ion ClO_2^{-} .





[2]

[3]



(e) Complete the electronic configuration of the chloride ion.

 $1s^2 2s^2 2p^6 3s^2 3p^6$ [1]

(f) Chlorine can react with aqueous sodium hydroxide as shown.

2NaOH(aq) + $Cl_2(g) \rightarrow NaCl(aq) + NaOCl(aq) + H_2O(I)$

Explain, in terms of oxidation numbers, what happens to the chlorine in this reaction.

Chlorine had undergone **disproportionation** since it is simultaneously reduced, as the oxidation number decreases from 0 in Cl_2 to -1 in CL, and oxidised, as the oxidation[1] number increases from 0 in Cl_2 to +1 in NaClO. [Total: 14]



Section B

Answer one question from this section in the spaces provided.

8 (a) (i) Define what is meant by the terms *acid* and *base* using the Brønsted–Lowry theory of acids and bases.

A Brønsted-Lowry acid is a proton (H^+) donor, while a Brønsted-Lowry base is

- a proton (H⁺) acceptor. [1]
- (ii) Identify the acid, the base, the conjugate acid and the conjugate base in the equation shown.

 $HSO_4^{-}(aq) + OH^{-}(aq) \rightarrow SO_4^{2-}(aq) + H_2O(I)$

 HSO_4^- is the acid, OH^- is the base, SO_4^{2-} is the conjugate base and H_2O is the

conjugate acid. [1]

(b) (i) Write the expression for the term *ionic product of water*, K_w , and give its units.

expression $K_w = [H^+][OH^-]$ units $mol^2 dm^{-6}$

(ii) The numerical value of K_w is 5.48 × 10⁻¹⁴ at 50 °C.

Calculate the pH of pure water at 50 °C.

Since $[H^+] = [OH^-]$ for pure water, $K_w = [H^+]^2$ $[H^+] = \sqrt{K_w} = \sqrt{5.48 \times 10^{-14}}$ $= 2.341 \times 10^{-7} \text{ mol dm}^{-3}$ $pH = -lg[H^+] = -lg(2.341 \times 10^{-7})$ = 6.63



[1]



(iii) A student suggests that pure water is neutral at 50 °C.

State whether or not you agree with the student.

Explain your answer.

Agree. This is because in pure water, regardless of the temperature, the [H⁺] equals

to the [OH-], so it is always neutral. [1]

(c) Describe and explain the variation in ionic radius across Period 3 of the Periodic Table for the elements Na to C*l*.

The ionic radius of the series of isoelectronic [Ar] anions, P^{3-} , S^{2-} and CL, are larger than that of the series of isoelectronic [Ne] cations, Na⁺, Mg²⁺, Al³⁺ and Si⁴⁺, since they possess one more quantum shell of electrons. Within each series, since the nuclear charge increases from Na to Si and from P to Cl due to the increasing number of protons, while the shielding effect remains the same as they are isoelectronic, the effective nuclear charge increases across the series of cations and the series of anions, leading to a decrease in the cationic radius from Na⁺ to Si⁴⁺, and anionic radius from P³⁻ to CL. [3]

(d) (i) State the formulae of the oxides of the elements Na to S where the element is in its highest oxidation state.

Na₂O, MgO, A*l*₂O₃, SiO₂, P₄O₁₀, SO₃

......[1]

(ii) The oxides of sodium and sulfur given in (d)(i) react with water.

Write an equation for each reaction and state the expected pH of the products.

$Na_2O + H_2O \rightarrow 2NaOH$	pH = 14
$SO_3 + H_2O \rightarrow H_2SO_4$	pH = 1 [2]

(e) The equation for the complete combustion of ethanol is shown.

 $C_2H_5OH(I) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(I)$ $\Delta H_c = -1367 \text{ kJ mol}^{-1}$

Ethanol does not burn until a flame is applied to it.

(i) Define the term standard enthalpy change of combustion.

It is the heat energy released when one mole of a substance is completely burnt in excess oxygen under standard condition, at a specified temperature, usually 298 K. [1]





(ii) Explain why ethanol does not burn until a flame is applied to it.

The combustion of ethanol has a high activation energy since it involves breaking

numerous covalent bonds, which is supplied by energy from the flame. [1]

(iii) Calculate the enthalpy change of combustion of ethanol using bond energy values from the *Data Booklet* and the energy cycle shown.



$$\Delta H_{c} = \sum BE(bonds broken) - \sum BE(bonds formed)$$

= BE(C-C) + 5 × BE(C-H)) + BE(C-O) + BE(O-H) + 3 × BE(O=O)
-(4 × BE(C=O in CO₂) + 6 × BE(O-H))
= 350 + 5 × 410 + 360 + 460 + 3 × 496 - (4 × 805 + 6 × 460)
= 4708 - 5980
= -1272 kJ mol⁻¹

[2]

(iv) Suggest two reasons why the value of ΔH_c calculated in (e)(iii) is different from the $-1367 \text{ kJ mol}^{-1}$ value quoted.

Firstly, the -1367 kJ mol⁻¹ value quoted is for formation of $H_2O(l)$ from ethanol(l), while that calculated in (e)(iii) is for formation of $H_2O(g)$ from ethanol(g). Secondly, the bond energies used in (e)(iii) are average bond energy values and not the actual bond dissociation energies for the specific compounds involved. [2]

(f) Ethanol can undergo an elimination reaction.

Write an equation for the reaction. State the reagents and conditions needed for this reaction.

$C_2H_5OH \rightarrow C_2H_4 + H_2O$	
excess concentration sulfuric acid, 170 °C	. [2]

[Total: 20]



9 (a) Define the term standard enthalpy change of neutralisation.

It is the heat energy released when one mole of a water is formed from reaction between

an acid and a base under standard condition, at a specified temperature, usually 298 K. [1]

(b) In an experiment to determine the maximum change in temperature when sodium hydroxide is added to hydrochloric acid, 25.0 cm³ of 1.00 mol dm⁻³ hydrochloric acid is transferred to a polystyrene cup.

The initial temperature of the hydrochloric acid before sodium hydroxide is added is measured and recorded.

5.0 cm³ portions of aqueous sodium hydroxide are added to the polystyrene cup. The temperature of the solution in the cup is measured after each addition. The maximum temperature occurs when complete neutralisation has been achieved.

The results are shown in Fig. 9.1.



Fig. 9.1





(i) Draw two separate straight lines of best fit.

The first line should take into account the increasing temperatures.

The second line should take into account the decreasing temperatures.

Extend these lines until they intersect (cross).

Use your graph to determine the maximum temperature rise, ΔT_{max} , of the experiment.

Show your working.

 $\Delta T_{\rm max} = 28.2 - 20.3 = 7.9 \ ^{\circ}{\rm C}$

 $\Delta T_{\max} = \dots ^{7.9} ^{\circ} C$ [2]

(ii) Use your graph to determine the volume of sodium hydroxide, $V_{\rm NaOH}$, required to neutralise the acid.

Show on your graph how you determined this value.

V_{NaOH} = 23.5 cm³ [1]

(iii) Using your answers to (b)(i) and (b)(ii), calculate the energy, in kJ, evolved during the reaction.

You should assume that the specific heat capacity of the reaction mixture is $4.18 \text{ Jg}^{-1} \text{ K}^{-1}$ and the density of each solution is 1.00 g cm^{-3} .

energy evolved = $mc\Delta T_{max}$ = (25.0 + 23.5) × 1.00 × 4.18 × 7.9 = 1601.567 $\approx 1.60 \text{ kJ}$

[1]

(iv) Using your answer to (b)(iii), calculate a value for the enthalpy change of neutralisation, in kJ mol⁻¹, for the reaction between hydrochloric acid and sodium hydroxide.

$$\Delta H_{\text{neut}} = -\frac{1.60}{n_{\text{H}_2\text{O}}} = -\frac{1.60}{n_{\text{H}_Cl}}$$
$$= -\frac{1.60}{\frac{25.0}{1000} \times 1.00}$$
$$= -\frac{-64.1 \text{ kJ mol}^{-1}}{1000}$$

[2]



c) (i) Ethanoic acid dissociates in water as shown in the equation.

$$CH_3COOH(aq) \iff CH_3COO^-(aq) + H^+(aq)$$

Write the expression for the acid dissociation constant, K_a and give its units.

$$K_a = \frac{\left[CH_3COO^{-}\right]\left[H^{+}\right]}{\left[CH_3COOH\right]}$$

(ii) Fluorine and bromine are in Group 17 of the Periodic Table.

The K_{α} value for hydrofluoric acid, HF, is 5.6 × 10⁻⁴.

The K_a value for hydrobromic acid, HBr, is much greater than 5.6 × 10⁻⁴.

Solutions of equal concentration of the two acids HF(aq) and HBr(aq) are prepared.

Suggest how the pH of these two solutions differ. Explain your answers in terms of the K_a values and the equilibrium positions in each solution.

The solution of HBr(aq) have a **much lower pH** than that of HF(aq). Since K_a of HBr is

much greater than that of HF(aq), this means that equilibrium for the dissociation of

HBr lies much more to the right hand side compared to that of HF. As a result, there is

a much higher [H⁺] in HBr(aq) than in HF(aq), and thus a much lower pH. [2]

(d) A buffer solution is prepared by dissolving ammonium chloride in aqueous ammonia.

 $NH_3(aq) + H_2O(I) \implies NH_4^+(aq) + OH^-(aq)$

 $NH_4Cl(s) + aq \rightarrow NH_4^+(aq) + Cl^-(aq)$

(i) Explain what is meant by the term *buffer solution*.

A buffer solution is one which resists changes in pH when small quantities of an acid

- or an alkali are added to it. [1]
- (ii) Write an equation to show what happens when a small amount of aqueous sodium hydroxide is added to the buffer solution.

 $\mathbf{NH}_{4}^{+} + \mathbf{OH}^{-} \rightarrow \mathbf{NH}_{3} + \mathbf{H}_{2}\mathbf{O}$ [1]

(iii) Write an equation to show what happens when a small amount of dilute hydrochloric acid is added to the buffer solution.

 $\mathbf{NH}_3 + \mathbf{H}^+ \to \mathbf{NH}_4^+$ [1]





(iv) Explain why it is necessary to add ammonium chloride to the aqueous ammonia to make the buffer solution.

A large reservoir of both the **base** (NH_3) and its **conjugate acid** (NH_4^+) is needed to

remove small amounts of acid and base added, respectively, to maintain the pH. [1]

(e) State and explain the trend in oxidising ability of the Group 17 elements going down the group.

The oxidising strength of the Group 17 elements **decreases** going down the group. This is because as we descend Group 17, the size of the atoms becomes bigger. The attraction of the halogen atom for an incoming electron becomes weaker as the electron is further from the nucleus. Hence ease of reduction, and as a result, oxidising strength decreases. [2]

(f) Write equations to show what happens when samples of sodium chloride, NaCl, and silicon tetrachloride, SiC l_4 , are added separately to water. Suggest the expected pH of the products.

$NaCl + aq \rightarrow Na^{+}(aq) + Cl^{-}(aq)$	pH = 7	
$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$	pH = 1	[2]

(g) Ethanoic acid undergoes a condensation reaction with propan-1-ol.

Name the product and state the conditions needed for the reaction.

Propyl ethanoate	
Heat with catalytic amount of concentrated sulfuric acid	[2]

[Total: 20]





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