

CHEMISTRY

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.

Answer **all** questions provided on the Question Paper.

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

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

This document consists a total of **10** printed pages.

1 (a) Carbon is less electronegative than chlorine.

(i) Define *electronegativity* and explain the above statement with reference to your definition. [2]

(ii) Explain how the electronegativity of an element varies [2]

- Across the Period
- Down the Group

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(b) Iodine is less electronegative than chlorine too.

Both ICl_3 and ICl_5 are possible compounds containing chlorine and iodine.

(i) Draw the *Lewis* structure of both compounds. [2]

(ii) Explain the geometry of ICl_3 and ICl_5 with respect to the central atom using the Valence Shell Electron Pair Repulsion Theory. [2]

(iii) Label the bond angle for both compounds in the Lewis structure you have drawn in (i). [1]

(iv) State the type(s) of intermolecular forces of attraction between molecules of ICl_5 . Explain how they arise. [3]

(v) ICl_3 can form a dimer with itself like aluminium chloride to form I_2Cl_6 . There are co-ordinate bonds formed in I_2Cl_6 .

Explain what are *co-ordinate bonds*, with reference to the structure of this dimer. [2]

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(c) Sodium is less electronegative than chlorine too.

When sodium metal and chlorine gas are mixed, a reaction occurs, forming sodium chloride, commonly known as table salt.

(i) With the aid of a labelled diagram, describe the structure and bonding in sodium. [3]

(ii) Write a balanced chemical equation of the formation of sodium chloride. [1]

(iii) With reference to structure and bonding, predict and explain the difference between the melting point of sodium chloride and ICl_5 . [2]

(iv) When a sample of bare sodium is left in air, a coating of sodium peroxide, Na_2O_2 , is formed. The oxidation state of sodium is +1.

Draw the dot-and-cross diagram of sodium peroxide. [1]

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2 (a) In organic chemistry, the use of a solvent to conduct a reaction matters.

(i) One type of solvent is a *protic* solvent. This means that molecules of such solvents have the ability to form hydrogen bonds with itself, and different molecules.

Name a *protic* solvent. With the aid of labelled diagrams, explain why this solvent is a *protic* solvent. [3]

Another type of solvent is a *polar aprotic* solvent. Molecules of such solvents cannot form hydrogen bonds with itself, but are *polar*.

(ii) Explain what makes a molecule *polar*. [1]

(iii) Formaldehyde, CH_2O , is a *polar aprotic* solvent. Draw the structure of formaldehyde, and label all dipole moments in formaldehyde. [2]

(iv) Explain if formaldehyde and water are miscible. [2]

(v) Another solvent is a *non-polar* solvent. 2 examples are liquid carbon dioxide and hexane.

Explain why *non-polar* solvents and *protic* solvents are generally not miscible. [2]

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- (b)** The carbon atom in formaldehyde is sp^2 hybridised.
- (i)** State the electronic configuration of carbon. [1]
- (ii)** Draw 2 energy level diagrams to illustrate sp^2 hybridisation for carbon. [2]
- (iii)** Draw and name **all** the outer orbitals in carbon. [2]
- (iv)** Illustrate the type(s) of bonding in the C-O bond of formaldehyde. [2]

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(c) When iodine is dissolved in hexane, a purple colouration is observed.

However, iodine is much less soluble in water compared to hexane. Aqueous iodine is light yellowish brown in colour.

A test tube of hexane contains iodine. Then, some water was added into the test tube. The test tube was then shaken vigorously, and left to stand.

Draw the appearance of the test tube after the solution was left to stand.

[2]

The density of hexane is lower than that of water.

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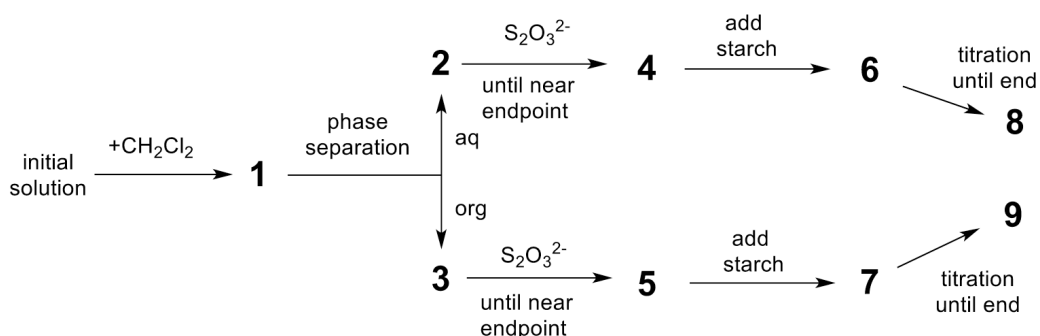
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(d) When iodine is dissolved in aqueous potassium iodide, a brown colouration is observed. This is due to the formation of the triiodide ion, I_3^- .

(i) On page 9, draw the Lewis structure of the triiodide ion. [1]

(ii) The following procedure was conducted:

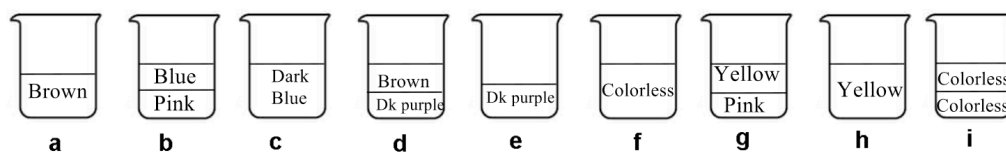
A few crystals of solid iodine were dissolved in 50.0 cm^3 of an aqueous solution of potassium iodide. Then, 50.0 cm^3 of dichloromethane, CH_2Cl_2 , was added, and the mixture was vigorously shaken until equilibration. After phase separation, each phase was titrated by 16.20 cm^3 (organic phase) and by 8.00 cm^3 (aqueous phase) of the standard aqueous solution of sodium thiosulfate in the presence of starch. The process is schematically represented below:



Sodium thiosulfate reacts with iodine to form colourless iodide ions. A dilute solution of aqueous iodine appears as yellow. When starch is added to iodine, a dark blue colouration is formed.

The figure below shows 9 different illustrations of the solutions at different stages of this process. ['Dk' means dark, 'aq' means aqueous, 'org' means organic.]

Iodine is dark purple in dichloromethane.



Match the stages on the scheme (1 to 9) to the schematic illustrations representing them (a to i). [4]

| Stage | Illustration | Stage | Illustration | Stage | Illustration |
|-------|--------------|-------|--------------|-------|--------------|
| 1 | | 4 | | 7 | |
| 2 | | 5 | | 8 | |
| 3 | | 6 | | 9 | |

[Total: 24]