

## O-level chemistry

### Separation of mixtures

A **mixture** is a substance, which consists of two or more substances/elements or compounds **NOT** chemically combined together.

Examples of mixtures include;- Ink, milk, paint are common examples of mixture. Note that all solutions are mixtures.

A **compound** is a substance, which consists of two or more elements chemically combined together.

Example

- Water is a compound of the elements Hydrogen (H) and Oxygen (O)
- Common salt (sodium chloride) is a compound of the elements sodium (Na) and Chlorine (Cl)

An **element** is a substance, which cannot be split/divided up into simpler substances by chemical means.

Common elements are: - oxygen, nitrogen sulphur, carbon, iron, copper

### Method of separation of mixtures

#### 1. Crystallization:

This is the process of obtaining pure crystals from solution.

#### Definition

A **solution** is a Uniform mixture of two or more substances.

A **solute** is the dissolved substance, e.g., sodium chloride.

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**A solvent** is a substance that dissolves a solute, e.g., ethanol, water, chloroform, etc.

Substances that dissolve in any solvent are said to be **soluble** in that particular solvent and those, which do not, are said to be **insoluble** substances and may settle down as sediments or may float in the solvent. E.g., chalk. They form what we call a suspension.

**A suspension** is a liquid containing small particles of solid spread throughout it and which settle on standing.

**A saturated** solution of a solute at a particular temperature is one which can dissolve no more solute in the presence of the solute.

**A suspension** differs from a solution in three ways:

- (a) It contains solid particles that can be seen.
- (b) Its solid particles settle on standing and
- (c) Filtration separates it into filtrate and a residue.

## 2. Sublimation

Is a process where by a solid, on heating changes directly into the vapor state without first becoming liquid and on cooling condenses directly into the solid form without passing through a liquid state.

Substances like iodine, iron (III) chloride, Ammonium chloride that sublime can be separated from those that do not sublime by heating the mixture in a dry test tube. Iodine, iron (III) chloride or ammonium chloride would sublime leaving the nonvolatile substance as a residue in the test tube

Sublimation may be demonstrated by heating either iodine or ammonium chloride crystals in a dry test tube

**Experiment :Action of heat on substances that sublime;**

### 1). Iodine (I<sub>2</sub>)

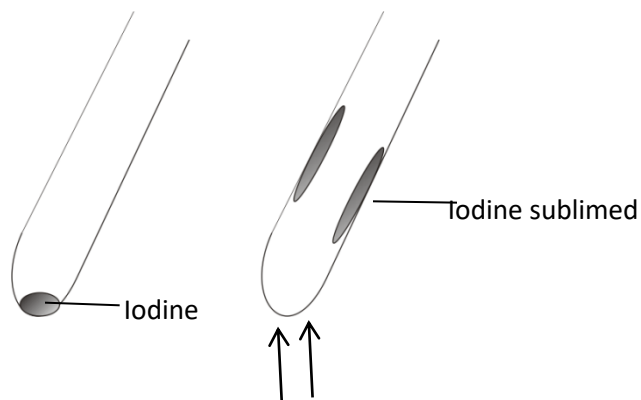
**Apparatus:** Test tube, test tube holder

**Materials:** Iodine

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Method: place iodine in a dry testtube and heat strongly



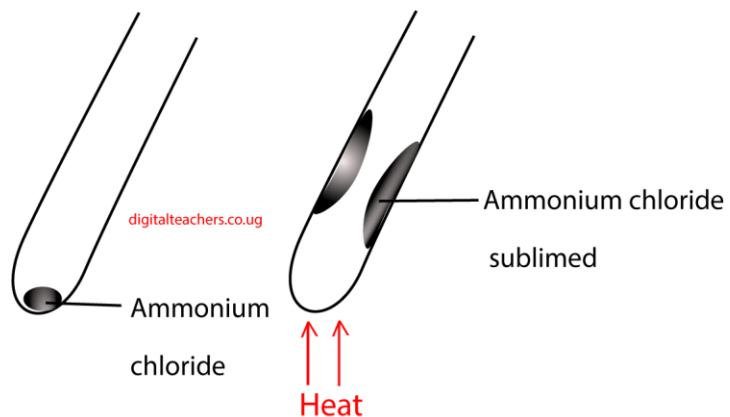
Observation: dense purple fumes of iodine sublime on the cooler parts of the test tube.

## 2). Ammonium chloride (NH<sub>4</sub>Cl)

**Apparatus:** Test tube, test tube holder

**Materials:** Ammonium chloride

Method: place ammonium chloride in a dry test tube and heat strongly



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Observation: Dense white fumes of ammonium chloride sublime on the cooler parts of the test tube.

## **Experiment**

### **Separation of ammonium chloride from sodium chloride**

You are provided with a mixture of sodium chloride and Ammonium chloride. Place the mixture in a dry test tube and heat the mixture strongly.

(a) State your observation and conclusion

### **Experiment : Separation of ammonia chloride from sodium chloride**

Apparatus

Test tube

Tongs

Material

A mixture of ammonium chloride and sodium chloride

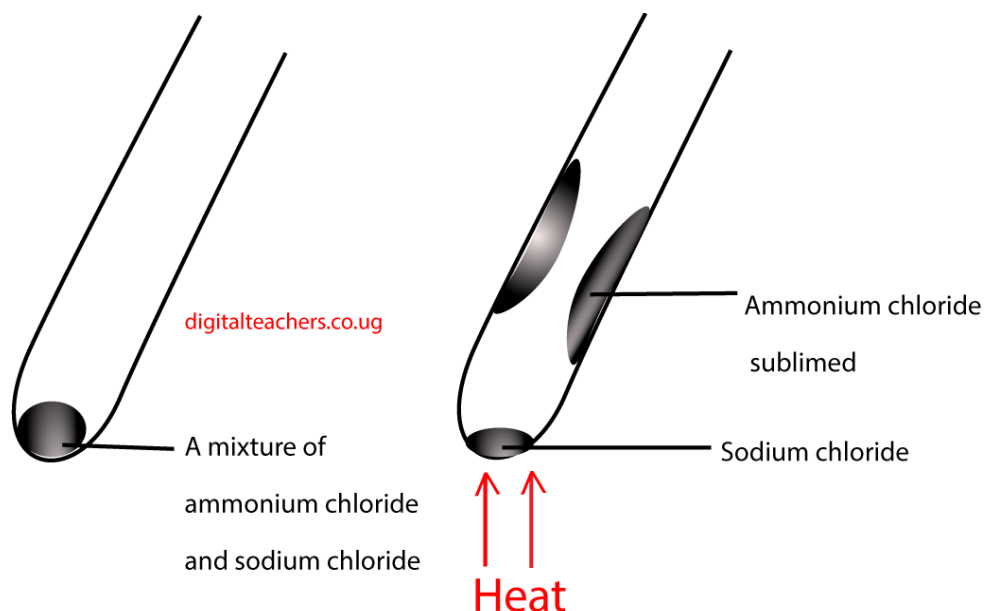
Heat source

Method

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Place the mixture of ammonium chloride and sodium chloride into a test tube and heat strongly.



### Observations:

Dense white fumes of ammonium chloride sublimed to the cool part of the test tube leaving sodium chloride at the bottom of the test tube.

### Conclusion:

Ammonium chloride can be separated from sodium chloride by sublimation.

## 3. Magnetism

A magnet can attract materials (metals) because the metals/materials being attracted have got some magnetic properties. Magnetic substances may be separated from nonmagnetic substance by use of a magnet.

### EXPERIMENT: Separating of a mixture of iron filing from sulphur

You are provided with a mixture of iron and sulphur. Place the mixture on a plain sheet of paper. Use the bar magnet provided to separate the two. (State your method, observations and conclusion)

Materials

Iron fillings

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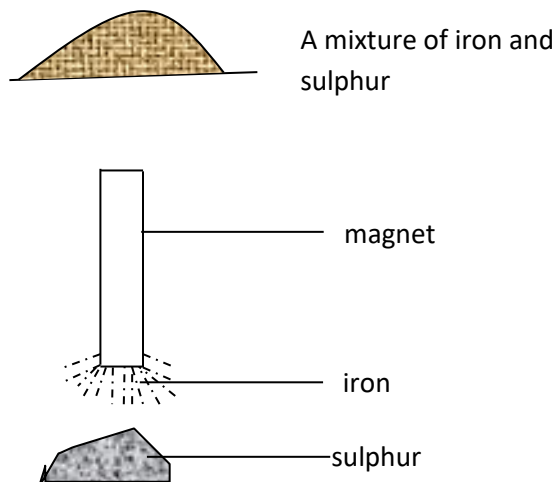


Sulphur

Magnet

### Method

- Place a mixture of sulphur and iron on sheet of paper
- Pass a magnet over the mixture.



### Observations

Iron filings are attracted on to the magnet leaving sulphur on the sheet of paper.

### Conclusion

Iron filings are separated from sulphur using a magnet because they have magnetic properties while sulphur does not.

#### 4. Chromatograph:

Is a process of separating colored substances by using porous material e.g. filter paper, based on their different rates of movement, using a suitable solvent e.g. alcohol (ethanol,), water.

- Colored materials found in leaves e.g. chlorophyll can be separated.
- The bands/lines/shades obtained after chromatography are referred to as **chromatograms**.
- The component which is more soluble in that solvent moves far away from the mixture.

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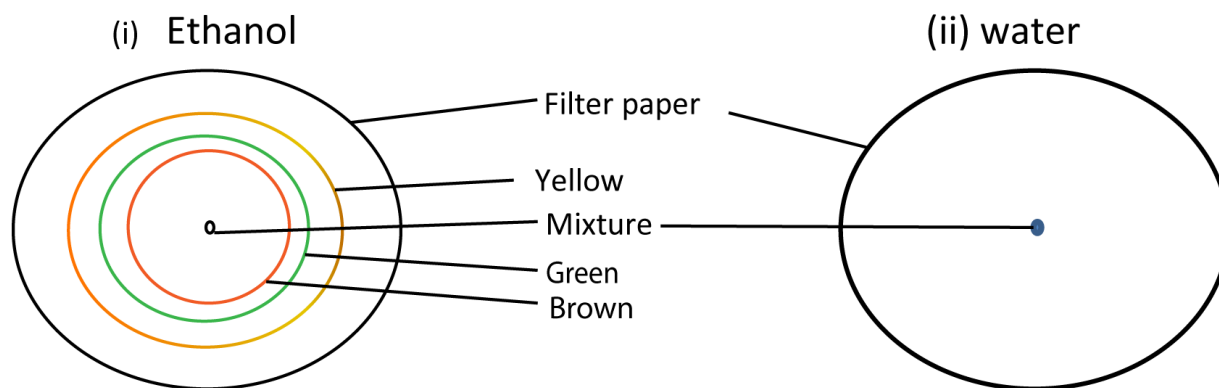
## Procedure

- (i) A drop of a mixture of colored material such as ink or chlorophyll is placed in the middle of a filter paper
- (ii) Add a suitable solvent such as ethanol dropwise. In each case a drop is allowed to dry before another is added.

**Observed a chromatogram of ring of different colors is obtained because each colored substance has different solubilities and moves at different rates.**

## Observation

The following colors were observed



Chlorophyll dyes did not separate when water was used because water is not a suitable solvent.

## Conclusion

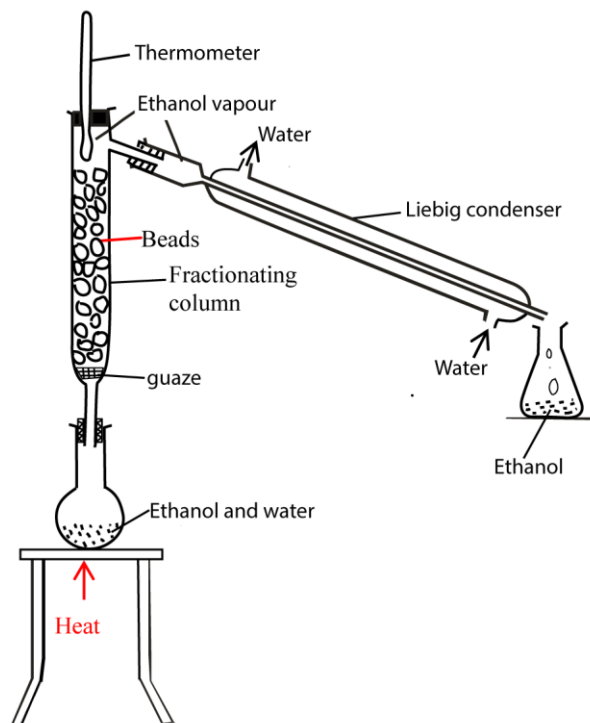
Chlorophyll/ ink is not a single component and the components in chlorophyll/ ink can be separated by chromatography.

## 5. Distillation

Is a process of boiling a liquid to form vapor, where the vapor condenses and collects as a distillate. The substance that forms vapor easily is said to be volatile.

Distillation is used to separate miscible substances (such as water and ethanol) that differ in boiling points. A substance that has a lower boiling point turns into vapor easily and is collected as a distillate.

Distillation apparatus

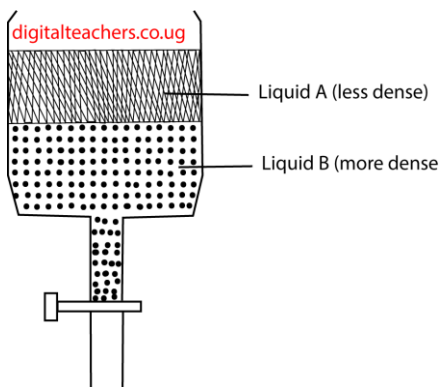


## 6. Immiscible liquids

Immiscible liquids are those that do not form a uniform mixture; i.e. they form separate layer. The less dense liquid settles on top.

Immiscible liquids are separated by a separating funnel

Separating funnel





## Alloys:

Pure metals are not usually strong. Their appearance, strength and resistance to corrosion can be improved by mixing with other elements. The mixtures are called alloys.

An alloy is a uniform mixture of metal with one or more metals or carbon.

### Examples of alloys

Alloy	Composition
Steel	Iron (Fe) and carbon (C)
Brass	Copper (Cu) and zinc (Zn)
Solder	Lead (Pb) and tin (Sn)
Duraluminium	Magnesium (Mg), copper(Cu) and aluminium (Al)
Bronze	Copper (Cu) and tin (Sn)
Cast iron	Iron (Fe), phosphorus (P), sulphur(S), silicon (Si), manganese (Mg)
Wrought iron	Iron (Fe) and carbon (C)

### Experiment : to study the difference between a mixture of iron (Fe) and sulphur (S) and a compound of iron sulphide (FeS)

	Test	Observation
	Heat a mixture of iron and sulphur in a dry test tube.	Black solid formed. $\text{Fe (s)} + \text{S(s)} \rightarrow \text{FeS (s)}$
Appearance	Look at the mixture through a magnifying glass	- The elements can be seen separately in the mixture. - The compound is homogeneous.
Water	-Add a little of the mixture to water in a test tube, shake and allow to stand. - Repeat with the compound	- The metal in the mixture separate first because it is denser and the sulphur floats. - The compound does not separate completely.
Dilute acids	-Add dilute hydrochloric acid or sulphuric acid to the mixture in the test tube and warm gently. - Repeat with the compound.	-The acid reacts with iron (or zinc) in the mixture, forming hydrogen which burns with a 'pop' sound, sulphur does not react. $\text{Fe (s)} + \text{H}_2\text{SO}_4 \text{(aq)} \rightarrow \text{FeSO}_4\text{(aq)} + \text{H}_2\text{(g)}$ The compound reacts to form hydrogen

		<p>sulphide, which smells like bad eggs and burns quietly with a blue flame.</p> $\text{FeS}_{(s)} + \text{H}_2\text{SO}_{4(aq)} \rightarrow \text{H}_2\text{S}_{(g)} + \text{FeSO}_{4(aq)}$ $2\text{H}_2\text{S}_{(g)} + 3\text{O}_{2(g)} \rightarrow 2\text{H}_2\text{O}_{(g)} + 2\text{SO}_{2(g)}$
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### Differences between a mixture and a compound

A mixture	A compound
- Energy is not given out or absorbed when a mixture is made.	Energy is given out or absorbed
- The substances in it can be <i>separated</i> by physical means.	The elements in it cannot be separated by physical means.
-Its <i>composition</i> is variable; the substances can be presented in any proportions by mass	Its composition is not variable; the elements are combined in definite proportions by mass.
-Its properties (e.g. color, density) are the average of those of the substance in it.	Its properties are quite different from those of the elements in it.

### Exercise

- Which of the following substances will melt on heating strongly?
  - Iodine
  - Sodium chloride
  - Ammonium
  - Iron III chloride
- Which one of the following is a method that can be used to separate a mixture of potassium chloride and charcoal?
  - Distillation
  - Magnetism
  - Sublimation
  - filtration
- Fractional crystallization is a method used to separate salts with different
  - Molecular masses
  - Boiling points
  - Density
  - solubility
- Which of the following is not a mixture?
  - Bronze
  - Steel

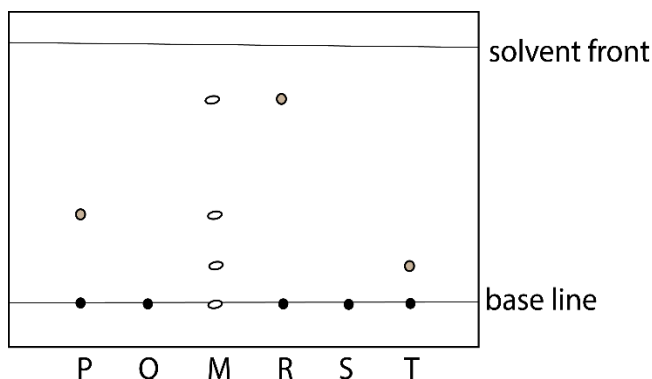
- C. Water
  - D. Air
5. The process used to obtain pure water from sea water is called
- A. Sedimentation
  - B. Filtration
  - C. Distillation
  - D. decanting
6. The pigments of a green leaf can be separated by
- A. Distillation
  - B. Fractional distillation
  - C. Evaporation
  - D. Chromatography
7. Which of the following is an alloy of lead?
- A. Brass
  - B. Bronze
  - C. Duralumin
  - D. Solder
8. Steel is an alloy of carbon and
- A. Zinc
  - B. Iron
  - C. Tin
  - D. Sulphur

9. Which of the following is miscible with water?
- A. Ethanol
  - B. Methylbenzene
  - C. Kerosene
  - D. petrol
10. Which of the following pairs of metals is used to make solder?
- A. Zinc and lead
  - B. Copper and aluminium
  - C. Tin and lead
  - D. Copper and zinc
11. An alloy of solder is made of
- A. Zinc and lead
  - B. Copper and aluminium
  - C. Copper and lead
  - D. Tin and lead
12. Which of the following mixtures is best separated by chromatography
- A. Ink
  - B. Crude petroleum
  - C. Water and oil
  - D. Water and ethanol
13. Which of the following substances sublimes
- A. ZnO
  - B. CaCl<sub>2</sub>
  - C. I<sub>2</sub>
  - D. P
14. The alloy of solder consists of
- A. Zinc and lead
  - B. Copper and lead
  - C. Copper and aluminium
  - D. Tin and lead
15. Sodium carbonate and sodium hydrogen carbonate can be separated by crystallization because the two salts have different
- A. Densities
  - B. Solubilities
  - C. Melting points
  - D. Boiling points
16. Brass is an alloy of
- A. Tin and copper
  - B. Lead and copper
  - C. Zinc and copper
  - D. Aluminium and copper
17. Which of the following mixtures is best separated by using a separating funnel?
- A. Oil and water
  - B. Sugar and water
  - C. Ethanol and water
  - D. Sand and water

- 18 Which of the following substances can be purified by sublimation?
- A. Sulphur
  - B. Phosphorus
  - C. Potassium chloride
  - D. Ammonium chloride
- 19 The main component of air are
- A. Oxygen and nitrogen
  - B. Oxygen and hydrogen
  - C. Nitrogen and carbon dioxide
  - D. Nitrogen and noble gases
- 20 Which of the following gases in atmosphere makes rain water acidic
- A. Carbon monoxide
  - B. Ammonia
  - C. Sulphur dioxide
  - D. Nitrogen
- 21 A bottle of copper (II) sulphate has been contaminated with sodium chloride. How can sodium chloride be removed from copper (II) chloride
- A. Place the mixture in a separating funnel
  - B. Add dilute acid to the mixture and then filter
  - C. Add silver nitrate to the mixture and filter
  - D. Add water and filter
- 22 Which of the following substances does not sublime when heated?
- A. Ammonium chloride
  - B. Iron (III) chloride
  - C. Iodine
  - D. Copper (II) oxide
- 23 Solder in an alloy made of
- A. Zinc and cadmium
  - B. Lead and tin
  - C. Copper and lead
  - D. Aluminium and iron
- 24 Which of the following gases are removed first before air is liquified?
- A. Nitrogen and oxygen
  - B. Water vapor and carbon dioxide
  - C. Carbon dioxide and oxygen
  - D. Water vapor and nitrogen
- 25 The best method that can be used to separate a mixture of alcohol and paraffin
- A. Filtration
  - B. Crystallization
  - C. Distillation
  - D. chromatography
- 26 Which of the following gases is obtained by fractional distillation?
- A. Oxygen
  - B. Ammonia
  - C. Sulphur dioxide
  - D. hydrogen

27. The best method for separating a mixture of ammonium chloride and sodium chloride is
- A. Decantation
  - B. Filtration
  - C. Distillation
  - D. Sublimation
28. Fractional crystallization can be used to separate a mixture in solution. The substances in the mixture must have
- A. A large difference in solubility
  - B. Very low boiling points
  - C. A hygroscopic property
  - D. Very high molecular mass
29. The separation of substances that make up ink by chromatography depend on the
- A. Solubilities of substances in the solvent
  - B. Size of the chromatography paper
  - C. Freezing point of substances
  - D. Osmotic pressure of the solution of ink
30. The components of ink can be separated by
- A. Distillation
  - B. Chromatography
  - C. Filtration
  - D. electrolysis
31. An alloy of solder consists of
- A. Zinc and lead
  - B. Copper and lead
  - C. Copper and aluminium
  - D. Tin and lead

- 32 A chromatogram of substances P, Q, R, S, T and mixtures, M, was developed as shown in figure below



- The figure shows that the mixture M consist of
- A. P, R, and T
  - B. R, S and T
  - C. P, Q and R
  - D. Q, R and S
- 33 Which of the following is soluble in water
- A. Ethanol
  - B. Methylbenzene
  - C. Kerosene
  - D. petrol
- 34 Which of the following pairs of metals are used to make solder
- A. Zinc and lead
  - B. Copper and aluminium
  - C. Tin and lead
  - D. Copper and zinc
- 35 The most efficient method for separating a mixture of copper sulphate and lead (II) sulphate is by
- A. Decantation
  - B. Filtration
  - C. Sublimation
  - D. Crystallization
- 36 The process of making steel from iron is called
- A. Galvanization
  - B. Metal plating
  - C. Glazing
  - D. Alloying
- 37 The substance that will not sublime when heated is
- A. Sulphur
  - B. Ammonium chloride
  - C. Iron (III) chloride
  - D. iodine

- 38 Steel is an alloy of iron and
- Zinc
  - Carbon
  - Tin
  - Sulphur
- 39 Which of the following can be separated by fractional crystallization
- Ammonium chloride and lead (II) chloride
  - Iron and Sulphur
  - Potassium nitrate and sodium nitrate
  - Sugar and sand
- 40 Which one of the following is an alloy of lead?
- Brass
  - Bronze
  - Duralumin
  - Solder
- 41 The substance that sublime when heated is
- Phosphorus
  - Carbon
  - Iodine
  - Sulphur
- 42 A mixture of two soluble salts can be separated by
- Filtration
  - Decanting
  - Fractional crystallization
  - Fractional distillation

For question 43 to 46 one or more of the answers given may be correct. Read the question carefully and then indicate the correct answer according to the following

- If 1, 2, 3, only are correct
  - If 1 and 3 only are correct
  - If 2 and 4 only are correct
  - If 4 only is correct
- 43 Which of the following is/are a mixture(s)?
- Diamond
  - Brass
  - Aluminium
  - steel
- 44 Which of the following is/are mixture(s)?
- Solder
  - Brass
  - Steel
  - lead



45. Which of the following methods can be used to separate a soluble solid from its solution?
1. Distillation
  2. Evaporation
  3. Crystallization
  4. chromatography
- 46 The pair(s) of the mixture below can be separated by sublimation
1. Sodium chloride and lead (II) chloride
  2. Copper (II) chloride and zinc nitrate
  3. Zinc sulphate and lead (II) nitrate
  4. Ammonium chloride and zinc chloride

For questions 47 to 52 consist of an assertion (statement) on the left-hand side and a reason on the right-hand side.

Select

- A. If both assertion and reason are true statements and the reason is a correct explanation of the assertion.
- B. If both assertion and reason are true statements and the reason is **not** a correct explanation of the assertion
- C. If the assertion is true but the reason is not correct statement.
- D. If the assertion is not correct but the reason is a correct statement.

Instruction summarized

Assertion	
A. True	True and a correct explanation
B. True	True but not a correct explanation
C. True	Incorrect
D. Incorrect	Correct

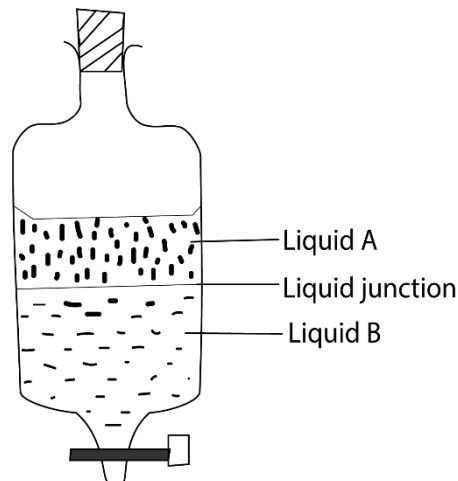
- |    |  |         |  |
|----|--|---------|--|
| 47 | The components of a plant pigments can be separated by chromatography              | because | the components of plant pigment move at different rates          |
| 48 | Ammonium chloride and sodium chloride are separated by sublimation                 | because | sodium chloride has a lower melting point than ammonium chloride |
| 49 | Crude petroleum is refined by fractional crystallization                           | because | its fractions have different boiling points                      |
| 50 | Water and alcohol can be separated by fractional distillation                      | because | They have different boiling points                               |
| 51 | A mixture of ammonium chloride and sodium chloride can be separated by sublimation | because | the salts have a common ion                                      |
| 52 | A mixture of water and petrol can be separated using a separating funnel           | Because | Water and petrol immiscible liquid                               |

- 53 Duralumin is an alloy of aluminium, copper and element D
- (a) (i) Identify D (½ marks)  
(ii) State one use of duralumin (½ marks)
- (b) Name the elements commonly used in making each of the following alloys, and in each case, give one use of the alloy
- (i) Steel  
Elements ..... (1mark)  
Use ..... (½ mark)
- (ii) Solder  
Elements ..... (1mark)  
Use ..... (½ mark)
- (c) State two reasons why alloys are commonly used instead of pure elements. (01mark)
- 54 A small amount of ethanol was added to a large amount of water and the mixture shaken (½ mark)
- (a) State what was observed (½ mark)
- (b) In the mixture in (a) state which one of the components is the
- (i) Solute (½ mark)  
(ii) Solvent (½ mark)
- (c) Name the method that can be used to separate the mixture formed in (a). (½ mark)
- (d) In another experiment, sim sim oil was shaken with water (½ mark)
- (i) State what was observed (½ mark)  
(ii) Give a reason for your answer in (d)(i) (1mark)  
(iii) Name the apparatus that would be used to separate the mixture in (d)(i) (½ mark)
- 55 State how the mixtures of substances can be separated (5marks)

Mixture	Method of separation
Sulphur and iron	
Ink	
Oxygen and nitrogen	
Iodine and potassium sulphate	
Sodium chloride and sodium carbonate	

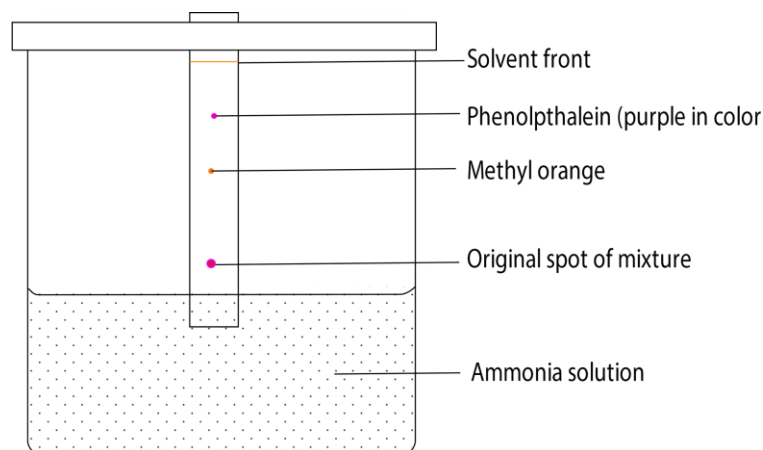
56

The figure below shows a setup of apparatus that was used for separating a mixture of water and ethanol



- (a) Identify Liquid A and B
- (i) A (01mark)
- (ii) B (01mark)
- (b) (i) State why A forms upper layer (2 marks)
- I State why the two liquids form a liquid junction as shown in figure above?
- 57 Name one process by which the components of the following mixtures can be separated:
- (a) Pigments of a green leaf (1mark)
- (b) Water and ethanol (1mark)
- (c) Iodine and potassium chloride (1mark)
- (d) Copper sulphate and sand (1mark)
- 58 A farmer on his way back home from the shop, he got an accident and his salt got mixed with soil. As a chemist, briefly explain how the farmer will recover his salt
- 59 (a) (i) State how you would separate a mixture of Sulphur and iron fillings using a physical method
- (ii) Explain the principle behind the method you have given in (a)(i) above
- (b) A mixture of 19sulphur and iron fillings was heated
- (i) State what was observed
- (ii) Write equation for the reaction
- 60 (a) State what would be observed when a mixture of iron fillings and Sulphur is warmed with
- (i) Carbon disulphide (1mark)
- (ii) Dilute sulphuric acid
- (b) A mixture of iron fillings and Sulphur was heated strongly
- (i) Name the substance formed (½ mark)
- (ii) Write equation for the substance formed in (b)(i) and hydrochloric acid
- 61 (a) A mixture consists of Sulphur and iron fillings. Explain briefly how a

- sample of Sulphur can be obtained from the mixture
- (b) A sample of the mixture in (a) was heated in a porcelain dish
- (i) State what was observed
- (ii) Write equation for the reaction that took place
- 62 (a) (i) State two properties that show that air is a mixture
- (ii) Name two gases other than oxygen, that are constituent of air and their approximate percentages in air
- (b) Describe an experiment to determine the percentage of oxygen in air. Show how the percentage of oxygen can be calculated
- I (i) State what is observed when burning Sulphur is lowered in a jar of oxygen.
- (ii) Write the name and formula of the product of the reaction between Sulphur and oxygen
- 63 A mixture of phenolphthalein and methyl orange was separated as shown in diagram below



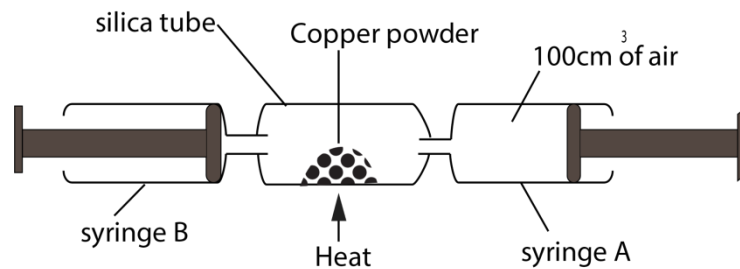
- (a) Name the method used in the separation of the mixture
- (b) (i) State the color of methyl orange in experiment.
- (ii) Give one other mixture can be separated by the method named above

## Answers

1	B	11	D	21	D	31	D	41	C	51	C
2	D	12	A	22	D	32	A	42	C	52	A
3	D	13	C	23	B	33	A	43	C	53	
4	C	14	D	24	B	34	C	44	A	54	
5	C	15	B	25	C	35	B	45	A	55	
6	D	16	D	26	A	36	D	46	D	56	
7	D	17	A	27	D	37	A	47	A	57	
8	B	18	D	28	A	38	B	48	C	58	
9	A	19	A	29	A	39	C	49	D	59	
10	C	20	C	30	B	40	D	50	A	60	

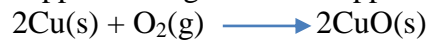
- 53 (a) (i) Magnesium  
Use: making aircraft
- (b) (i) Iron and carbon  
Use: making cutlery, sauce pans, bridges
- (ii) Tin and lead  
Uses: welding
- (iii) - Are resistant to corrosion  
- Are tougher than metals
- 54 (a) Dissolves
- (b) (i) Ethanol  
(ii) Water
- (c) Distillation
- (d) (i) Forms a layer on top  
(ii) Sim sim oil is immiscible with water  
(iii) Separating funnel
- 55 Sulphur and iron – use a magnet  
Ink – chromatography  
Oxygen and nitrogen – distillation  
Sodium chloride and sodium carbonate – fractional crystallization
56. (a) A – kerosene  
B – water
- (b) (i) Is less dense than water  
(ii) They are immiscible
- 57 (a) Chromatography  
(b) Fractional distillation  
(c) Sublimation  
(d) Filtration

- 58
- The dirty salt is mixed with water and filtered. The soil remains on filter paper while the salt is collected in solution as filtrate.
  - The filtrate is evaporated to dryness to recover the salt
- 59 (a) (i) Pass a magnet over a mixture of iron and sulphur. Iron fillings are attracted leaving sulphur.
- (ii) Iron is magnetic and is attracted to the magnet while sulphur is not
- (b) (i) Iron reacts vigorously with sulphur forming a black solid
- (ii)  $\text{Fe(s)} + \text{S(s)} \longrightarrow \text{FeS(s)}$
- 60 (a) (i) In carbon disulphide, Sulphur dissolves to form solution
- (ii) In sulphuric acid; effervescence is observed
- $\text{Fe(s)} + 2\text{H}^+(\text{aq}) \longrightarrow \text{Fe}^{2+}(\text{aq}) + \text{H}_2(\text{g})$
- (b) (i) Iron (II sulphide)
- (ii)  $\text{FeS(s)} + 2\text{H}^+(\text{aq}) \longrightarrow \text{Fe}^{2+}(\text{aq}) + \text{H}_2\text{S(g)}$
- 61 (a) A magnet is passed over a mixture of iron and sulphur, iron fillings are attracted to the magnet leaving sulphur on paper.
- (b) (i) Iron and sulphur combine to form black solid of iron (II) sulphide
- (ii)  $\text{Fe(s)} + \text{S(s)} \longrightarrow \text{FeS(s)}$
- 62 (a) (i) Air is a mixture because it can be separated by physical mean and has variable composition
- (ii) Nitrogen is 78%  
Carbon dioxide is 0.03%
- 63 (a) Paper chromatography
- (b) (i) Orange; methyl orange is yellow in alkaline medium
- (ii) Colors in Ink, pigments in chlorophyll



- Place copper turnings in combustion tube.
- Connect two syringes as shown in the figure above; syringe A contains 100cm<sup>3</sup> of air while syringe B is empty.
- Heat copper turning while passing the air continuously from syringe to syringe over the copper turnings until no further change in the volume of air.
- Push the air in one syringe and read the final volume Vcm<sup>3</sup>
- Calculate the percentage of oxygen as  $\left(\frac{100-V}{100}\right) \times 100\%$

NB. The reduction in volume of air is the volume of oxygen removed by copper turnings to form copper oxide



- (c) (i) Burns with a blue flame producing a choking gas that turns potassium dichromate paper from orange to green.
- (ii) Sulphur dioxide,  $\text{SO}_2$ .