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| Name: | Target Grade: | Actual Grade: |
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SEPARATION TECHNIQUES MCQ and STRUCTURED QUESTIONS

READ THESE INSTRUCTIONS FIRST

INSTRUCTIONS TO CANDIDATES

1. Find a quiet, comfortable spot free place from distractions.
2. Spend one minute on each mark.
3. Time yourself for every single question.
4. Every chapter has their own question types. Ensure that you know the different question type for each chapter.
5. Make a conscientious effort to remember your mistakes, especially in terms of answering techniques. E.g Take a picture for the mistakes that you made, keep it in a photo album, and revise it over and over again.
6. Highlight question types that you tend to keep making mistakes and review them nearing exams.
7. Always review the common questions and question type that you tend to make mistakes nearing exams.
8. During exams, classify the question type and recall what you have learnt, how you need to analyse the questions for the different question type, what you need to take note of and answer with the correct answering techniques!

✨ Wishing you all the best for this test!

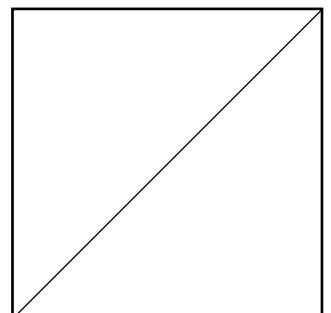
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Bright Culture 🧡

If you are struggling in this paper, means you need to work harder!

If you need any professional guidance and further advice on how to advance, feel free to WhatsApp us at 91870820 or find us at www.bright-culture.com/. We are committed to connect you to your future to reach your goals.

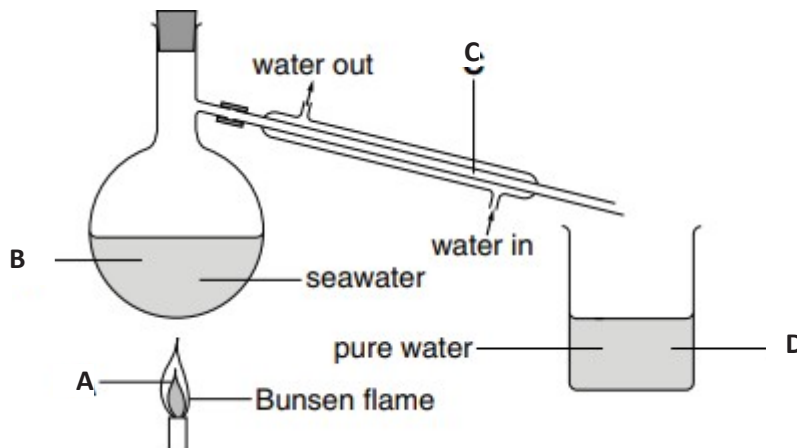
MARKS



SEPARATION TECHNIQUES MCQ

Paper 1

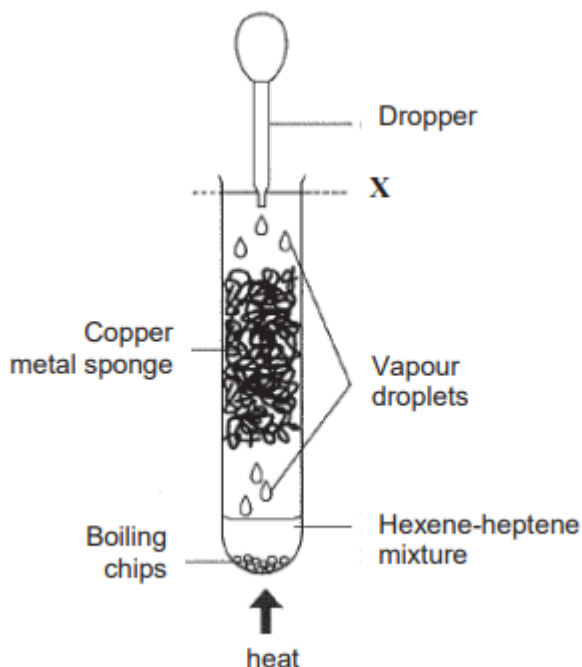
- 1 The diagram shows how to obtain pure water from seawater.
Where do water molecules lose energy?



Refer to the following to answer questions **below**.

1-hexene and 1-heptene are two members of the alkene class of hydrocarbons.

A small amount of mixture of 1-hexene and 1-heptene was placed in a boiling tube and gently heated to boiling in a sand bath using the following setup:



Droplets were formed and could be seen condensing on the sides of the tube. When the vapour condensation line reached the level marked X, the hot vapours were very slowly withdrawn and condensed by using a small dropper.

What is the purpose of the copper metal sponge?

- A Minimises contact of the mixture with air.
- B Prevents the two compounds from escaping.
- C Acts as a catalyst to speed up the reaction of the two compounds.
- D Provides a large surface area for repeated vapourisation and condensation.

2 What process is demonstrated in this experiment?

- A Cracking
- B Combustion
- C Addition reaction
- D Fractional distillation

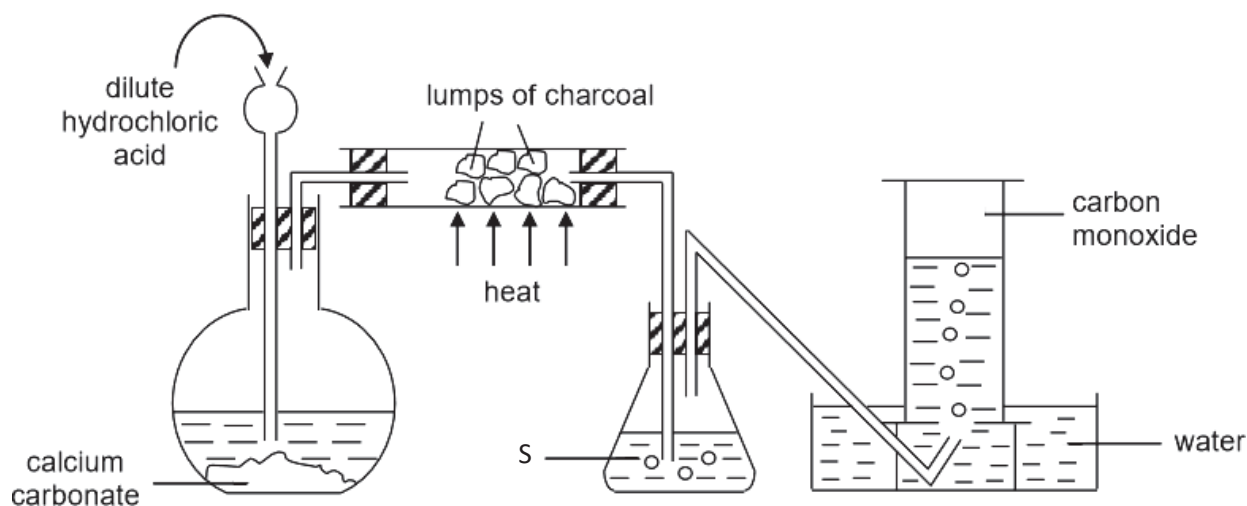
3 The properties of two substances are shown in the table.

| substance | melting point/ °C | boiling point/ °C | solubility in water |
|-----------|-------------------|-------------------|---------------------|
| 1 | - 8 | 67 | insoluble |
| 2 | - 95 | 210 | soluble |

Which is the best method to separate these two substances at room temperature and pressure?

- A filtration
- B paper chromatography
- C separating funnel
- D simple distillation

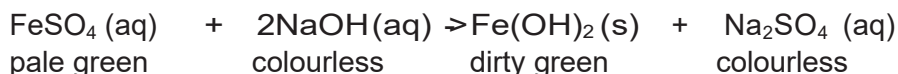
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What is the purpose of solution S?

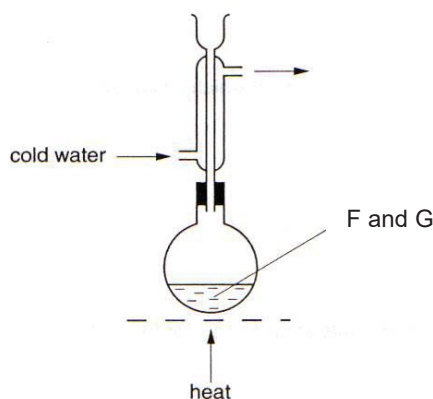
- A to remove the presence of carbon dioxide gas
- B to remove the presence of hydrogen chloride gas
- C to remove the presence of water vapour
- D to prevent water from being drawn into the hot charcoal

- 5 The reaction between aqueous iron(II) sulfate and aqueous sodium hydroxide is shown below.



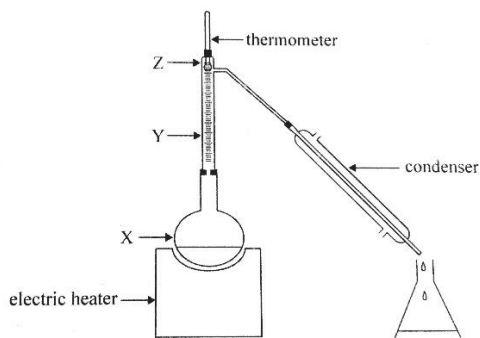
Which method could be used to separate the products?

- A crystallization
 B distillation
 C filtration
 D separatory funnel
- 6 The diagram shows the apparatus used for the slow reaction between liquid F (boiling point 57°C) and liquid G (boiling point 80°C).



What is the purpose of the condenser?

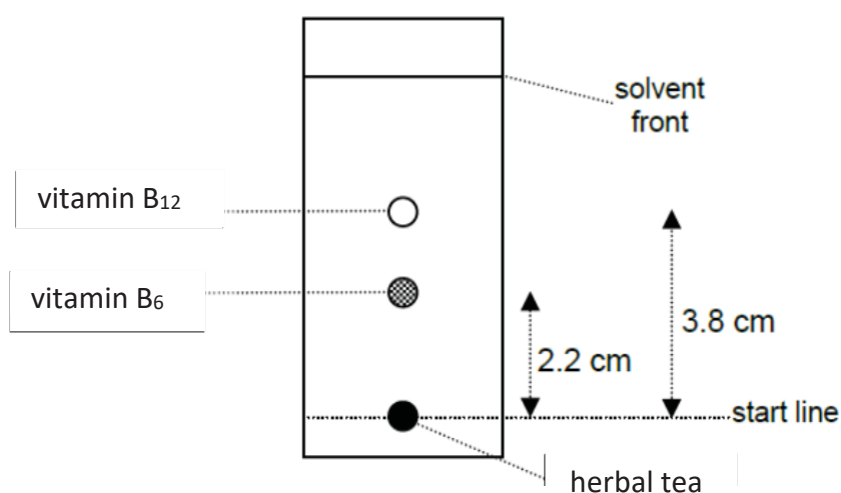
- A to enable F and G to mix more efficiently
 B to prevent the mixture from getting too hot
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- 7 A liquid mixture of 50% ethanol and 50% water was distilled in the apparatus shown below. The boiling point of ethanol is 78°C and that of water is 100°C . As the mixture was heated the temperature shown by the thermometer initially rose but then remained constant at 78°C for some time.



Which of the following statements about percentage of ethanol in the vapours shown at points X, Y and Z, when the temperature is at a constant 78°C, is true?

- A The percentage of ethanol in the vapour at X is equal to 50%.
- B The percentages of ethanol in the vapour increase in order at positions X, Y and Z.
- C The percentages of ethanol in the vapour at Y and Z are equal but greater than at X.
- D The percentages of ethanol in the vapour at X, Y and Z are equal but greater than 50%.

- 8 A sample of herbal tea containing two water- soluble vitamins was analysed during chromatography with water as a solvent. When the solvent front reached the position indicated, the chromatogram was placed under ultra-violet light. The following chromatogram was obtained.



Given that the R_f value of vitamin B12 is 0.34, determine the R_f value of vitamin B6.

- A 0.20
- B 0.50
- C 0.56
- D 0.73

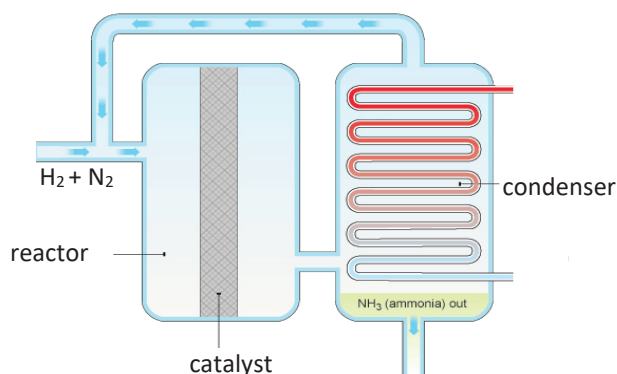
- 9 The following steps were carried out to prepare magnesium chloride.

| | |
|-----|--|
| I | Add excess magnesium carbonate to hydrochloric acid. |
| II | Heat the solution until it is saturated. |
| III | Filter , wash and dry the crystals. |

Which of the following steps should be taken to ensure that the procedure is successful in order to obtain the pure salt?

- A Filter to get rid of the excess magnesium carbonate before carrying out step II
- B Add excess hydrochloric acid instead of magnesium carbonate in step I.
- C Evaporate the solution to dryness in step III.
- D The crystals should not be washed in step III.

- 10 Ammonia is produced by Haber process as shown in the diagram.



Which one of the following processes separates ammonia from the reaction mixture?

- A cooling the gaseous mixture
- B distillation of the gaseous mixture
- C filtering out the other gases by passing through the condenser
- D pass the gaseous mixture through fused calcium oxide

Refer to the following for questions below.

- 11 The boiling points of some elements found in a sample of air are given below.

| Element | Boiling Point/ °C |
|----------|-------------------|
| Argon | -186 |
| Helium | -269 |
| Neon | -246 |
| Nitrogen | -196 |
| Oxygen | -183 |

Which elements are gases at -190 °C?

- A Argon and oxygen
- B Argon, helium and nitrogen
- C Helium and neon
- D Helium, neon and nitrogen

- 12** The sample is liquefied and separated using fractional distillation.

Which gas will be distilled off first, and which will be distilled off last?

| | First | Last |
|----------|--------------|-------------|
| A | Argon | Nitrogen |
| B | Helium | Oxygen |
| C | Neon | Argon |
| D | Oxygen | Neon |

- 13** A sample of sodium chloride was accidentally added to cooking oil in a beaker. Oil dissolves in ethanol.

Which of the following shows the best sequence of steps to separate and obtain a pure sample of sodium chloride from this mixture?

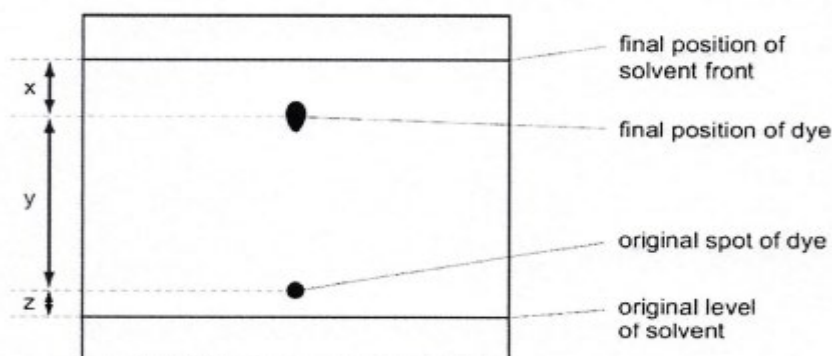
- A** dissolve in water → collect aqueous layer → evaporation to dryness
B dissolve in water → simple distillation → evaporation to dryness
C filtration → dissolve the residue in water → simple distillation
D filtration → wash residue with ethanol → dry residue with filter paper
- 14** The table below shows the colours and solubility of solids **W**, **X**, **Y** and **Z** in water.

| solid | colour | solubility in water |
|--------------|---------------|----------------------------|
| W | blue | insoluble |
| X | blue | soluble |
| Y | white | insoluble |
| Z | white | soluble |

A mixture containing two of the solids is added to excess water, stirred and filtered. At the end of the experiment, a blue filtrate and a white residue are obtained.

Which two solids are present in the mixture?

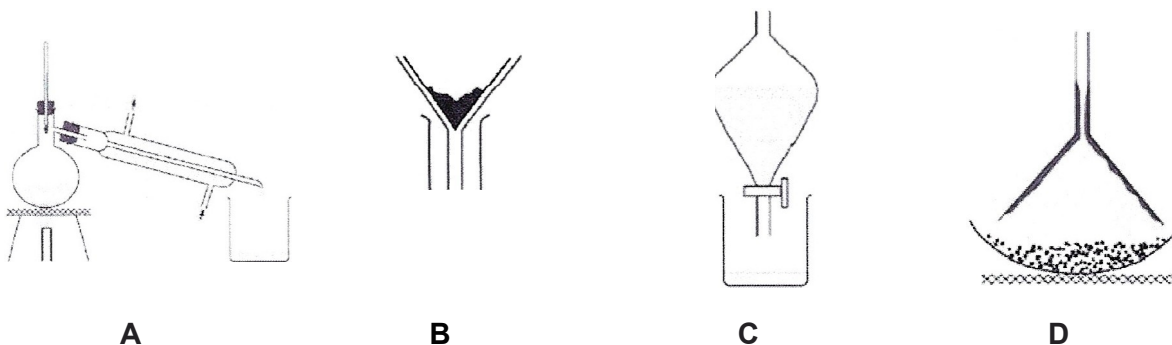
- A** **W** and **X**
B **W** and **Y**
C **X** and **Y**
D **X** and **Z**
- 15** The diagram shows the chromatogram obtained by analysis of a single dye.



Which of the following gives the R_f value of the dye?

- A** $\frac{x}{x+y}$
- B** $\frac{y}{x+y}$
- C** $\frac{x}{x+y+z}$
- D** $\frac{y}{x+y+z}$

16 Which of the following apparatus should be used to separate a mixture of iodine and sodium chloride?



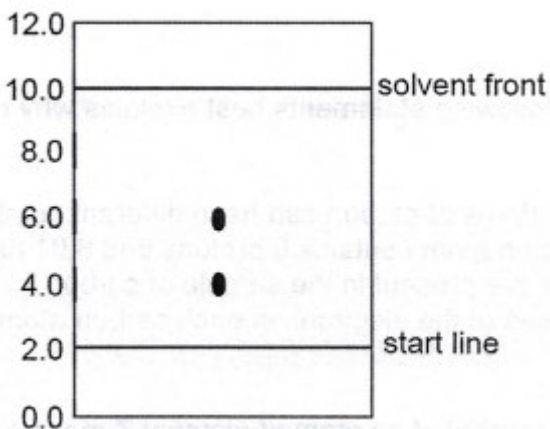
17 The solubilities of two samples, **A** and **B**, in dichloromethane solvent are shown below.

| Sample | Mass of sample dissolved in 100.0 g of dichloromethane at 25 °C/g |
|----------|---|
| A | 40.0 |
| B | 52.0 |

Paper chromatography was performed on a mixture of samples **A** and **B**, using dichloromethane solvent. The resulting chromatogram is shown below, with distance markings (in centimeters) on the left of the chromatogram indicating the spots' positions.

What is the R_f value of sample **B** in dichloromethane?

- A** 0.60
- B** 0.50
- C** 0.40
- D** 0.25



- 18** Which procedure shows the best method to obtain a pure sample of silver nitrate, from a mixture of silver nitrate and silver chloride salts?

| | step 1 | step 2 | step 3 | step 4 |
|----------|-------------|-----------------|-----------------|-----------------|
| A | dissolution | filtration | evaporation | crystallisation |
| B | dissolution | crystallisation | filtration | evaporation |
| C | dissolution | evaporation | crystallisation | filtration |
| D | filtration | dissolution | crystallisation | evaporation |

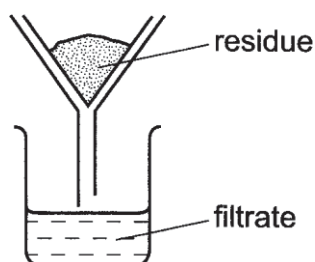
- 19** Which of the following pairs of substances can be separated by heating?

- A** ammonium chloride and potassium iodide
- B** copper (II) nitrate and potassium iodide
- C** ammonium chloride and iodine
- D** sodium chloride and copper (II) nitrate

- 20** The table shows the colours and the solubilities in water of four solids.

| solid | colour | solubility in water |
|-------|--------|---------------------|
| W | blue | insoluble |
| X | blue | soluble |
| Y | white | insoluble |
| Z | white | soluble |

A mixture containing two of the solids is added to excess water, stirred and filtered. A blue filtrate and a white residue are obtained.

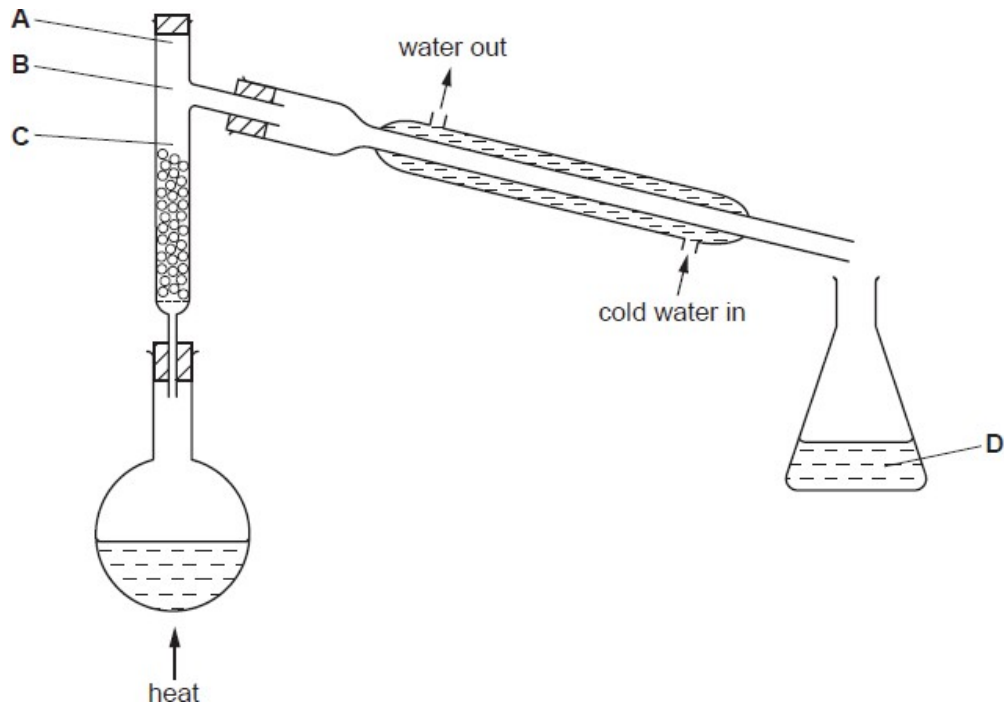


Which two solids are present in the mixture?

- A** W and X
- B** W and Y
- C** X and Y
- D** X and Z

- 21** The fractional distillation apparatus shown is being used to separate a mixture of two liquids. A thermometer is missing from the apparatus.

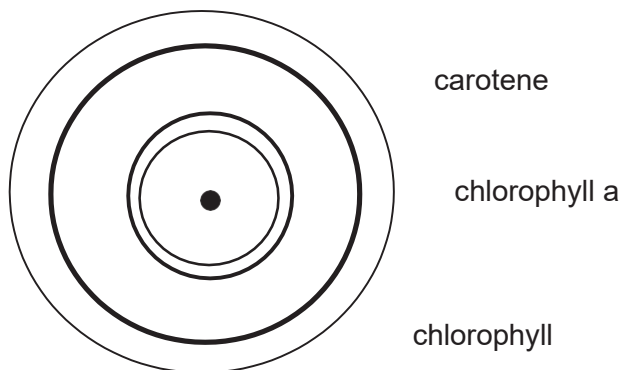
Where should the bulb of the thermometer be placed?



SEPARATION TECHNIQUES STRUCTURED QUESTIONS

Paper 2 Section A

- 1 Spinach is an edible plant that has a deep green colour. The following chromatogram is obtained when water-acetone mixture is added to a drop of spinach extract in the centre of a piece of filter paper.



- (a) State the property which allows the components of the spinach extract to be separated using chromatography.

.....
[1]

- (b) The experiment was repeated using a typical chromatography paper as shown below.



Draw and label the expected positions of the components of spinach extract on the chromatogram. [2]

- (c) State one experimental procedure that should be followed to obtain a good **separation** of the components.

.....
[1]

(d) Suggest why a water-acetone mixture is used as the solvent, instead of just a pure water or pure acetone solvent.

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

[Total: 5]

2 Cadmium is in the same group of the Periodic Table as zinc. Cadmium carbonate is insoluble in water and reacts in the same way as zinc carbonate with dilute acids. Cadmium sulfate is soluble in water.

Describe how you would prepare a pure, dry sample of cadmium carbonate, starting from cadmium sulfate.

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.....
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.....
.....
..... [4]

[Total: 9]

3 Aspirin is a medicine that is used as a painkiller. It is made from salicylic acid.

(a) A student makes a sample of aspirin. She thinks it contains some impurities.

- The student tests the melting point of the sample of aspirin.

Explain how she can use the result of the test to find out whether the sample contains impurities.

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

- The student uses chromatography to compare the sample of aspirin in (a) with pure samples of aspirin and salicylic acid.

Fig. 9.1 shows the results of the chromatogram.

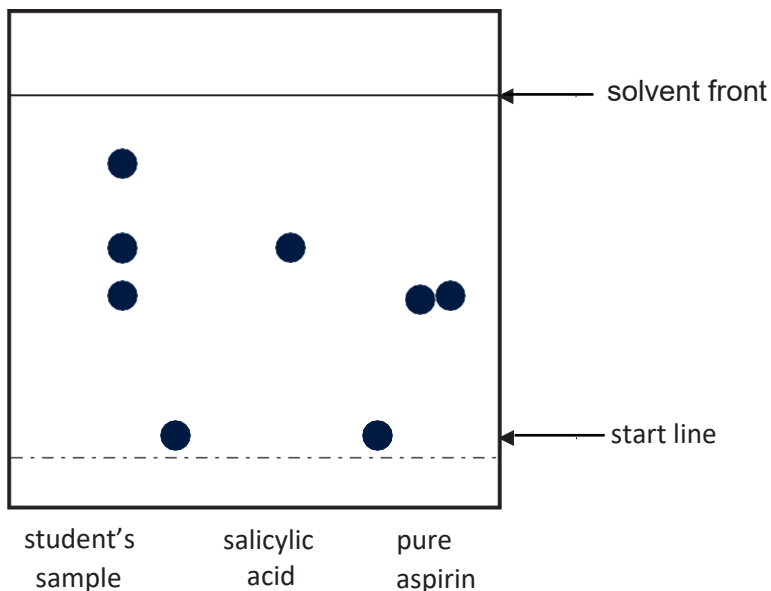


Fig. 9.1

Is the student's sample of aspirin pure? Explain your answer.

.....
 [2]

- 4 (a) (iii) In another chromatography using pure samples of aspirin and salicylic acid, the solvent was allowed to travel 9 cm from the start line.

Table 9.1 shows the R_f values of pure aspirin and salicylic acid.

Table 9.1

| substance | aspirin | salicylic acid |
|-----------------------|---------|----------------|
| R _f values | 0.56 | 0.654 |

Using the information provided in Table 9.1, calculate the distance travelled by aspirin.

distance =cm [1]

- (b) The student buys a few packets of aspirin tablets from a store and performs a titration using a crushed tablet and aqueous sodium hydroxide.

The formula for aspirin can be represented $\text{C}_6\text{H}_4(\text{COOH})_2$.

The equation for the reaction between aspirin and aqueous sodium hydroxide is shown below.



Table 9.2 shows the results of the student's titration.

Table 9.2

| | |
|--|--------------------------|
| concentration of aqueous NaOH used | 0.10 mol/dm ³ |
| volume of aqueous NaOH needed for neutralisation | 15.90 cm ³ |
| relative molecular mass of aspirin | 180 |

- Calculate the mass of aspirin, in mg, in one tablet. Leave your answer in 3 significant figures. (1 g = 1000 mg)

mass =g[3]

- (b) (ii) It is known that some aspirin tablets also contain citric acid. The student repeats the titration using one of these tablets.

- Explain why the mass of aspirin calculated in the second titration is different from that in (b)(i)

.....

.....

.....

[2]

[Total: 10]

5 The table below shows some information about substances **A** to **F**.

| substances | melting point/°C | boiling point/°C | conducts electricity when solid | dissolves in water |
|------------|----------------------------------|------------------|---------------------------------|--------------------|
| A | Turns directly from solid to gas | | No | slightly |
| B | 1583 | 2862 | Yes | No |
| C | 1873 | 2230 | No | No |
| D | -114 | 78 | No | Yes |
| E | 0 | 100 | No | - |
| F | -97 | 40 | No | No |

Using the information provided, suggest the best separation technique to separate the following mixture.

- (a) A and B
- (b) C and D
- (c) D and E
- (d) E and F [4]

6 A series of chromatography experiments were carried out on substances **A**, **B**, **C** and **D** to determine their *R_t* values when the chromatogram was developed with different solvents. The results of the experiments are shown in Fig. 1A below.

| Substance | <i>R_t</i> value when solvent is: | | |
|-----------|---|---------|-----------|
| | Water | Ethanol | Propanone |
| A | 0.72 | 0.54 | 0.00 |
| B | 0.53 | 0.62 | 0.84 |
| C | 0.04 | 0.16 | 0.54 |
| D | 0.55 | 0.45 | 0.31 |

Fig.1A

Substances **A** to **D** are all colourless and the chromatograms are all treated with locating agents in order to determine their positions and hence *R_t* values.

- (a) A student applied universal indicator as a locating agent to the chromatograms of substance **A**.

It was found that the spot for **A** was stained red for the chromatogram of **A** when developed in water, but the spot for **A** remains green when the chromatogram of **A** was developed in ethanol.

- (i) Suggest the likely pH of the spot for **A** when its chromatogram was developed in water.

..... [1]

- (ii) Suggest and explain why the spot for **A** remains green when its chromatogram was developed in ethanol.

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

- (b) Explain briefly why the *R_t* value for **A** is 0.00 when propanone is used as the solvent.

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

- (c) A student carried out an experiment on an un(b) known sample using water as the solvent and a spot with an *R_t* value of 0.54 was located.

- (i) Suggest and explain which two substances could have given rise to this particular spot with an *R_t* value of 0.54 in the unknown sample.

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

- (ii) Describe a method to identify which of the two substances give rise to the spot with an *R_t* value of 0.54. Explain your reason for the method described.

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

(d) A student set up a chromatography experiment as shown in Fig. 18.

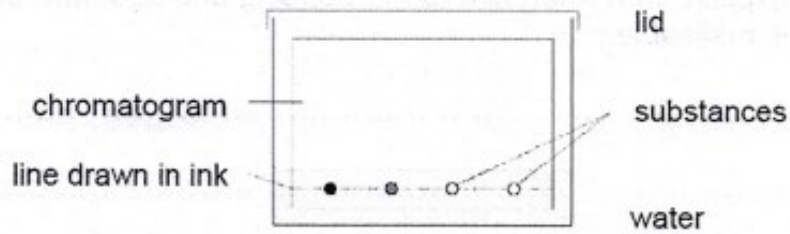


Fig.1B

Identify one error made in the set up in Fig. 1B.

Explain the effect of this error on the experiment.

error

.....

effect

.....[2]

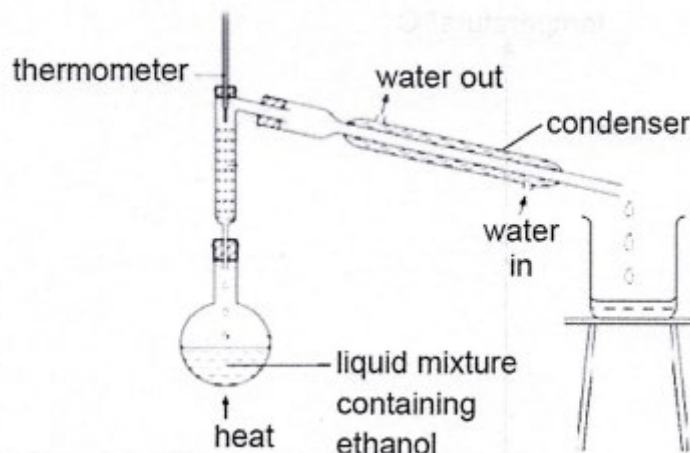
[Total: 10 marks]

7 The physical properties of five substances are shown in the table below. One of these substances is ethanol, while the other four unknown substances are labelled as **W**, **X**, **Y** and **Z**.

| substance | melting point/°C | boiling point/°C | soluble in ethanol | conducts electricity in solid state |
|-----------|------------------|------------------|--------------------|-------------------------------------|
| w | -98 | 65 | yes | no |
| X | -30 | 174 | no | no |
| Y | 153 | 310 | yes | no |
| Z | 842 | 1484 | no | yes |
| ethanol | -114 | 78 | N.A. | no |

(a) Samples of **W**, **X**, **Y** and **Z** were **individually** mixed with ethanol, and stored in four separate containers at room temperature.

One of the four unknown substances shown in the table above can be separated from ethanol using the set-up shown below.



(i) Name the technique used to separate the liquids in the mixture.

.....[1]

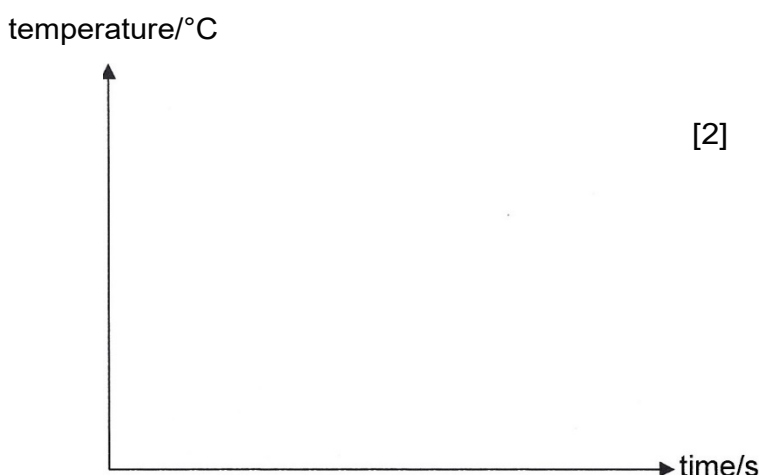
(ii) State the purpose of the condenser in the set-up shown above.

.....[1]

(iii) By making use of the information provided in the table, state which substance, when mixed with ethanol, can be separated using the set-up shown above. Explain your answer.

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

(iv) Using the axes provided, sketch how the temperature indicated by the thermometer varies with time when the mixture in (a)(iii) is heated from 25 °C to 90 °C. Label your axes with relevant information from the table above.



- (v) Apart from the substance in (a)(iii), suggest appropriate separation methods to obtain the three remaining unknown substances from ethanol.

| substance being mixed with ethanol | method to obtain substance from ethanol mixture |
|------------------------------------|---|
| | |
| | |
| | |

[3]

- (b) Having carefully studied the information in the table, Kent, a Chemistry student, claimed that substance **Z** is a metal.

Using information from the table, state a piece of evidence which would **best** support Kent's claim.

With reference to the structure and bonding in metals, explain how this piece of evidence suggests that substance **Z** is a metal.

Evidence

Explanation

.....

.....

.....

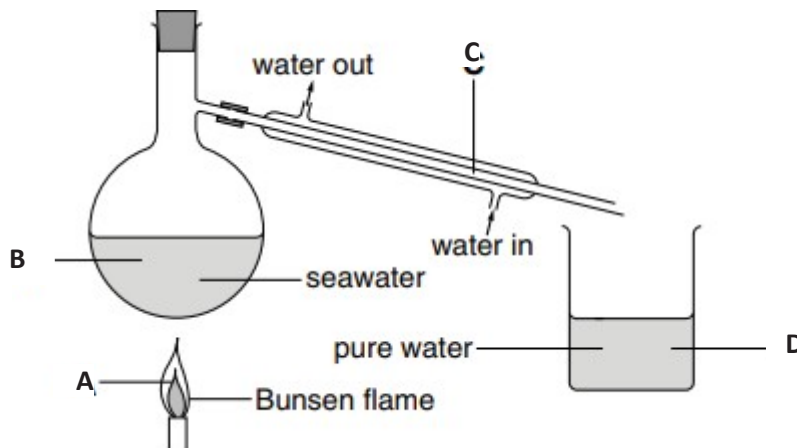
.....[3]

[Total: 12]

ANSWERS FOR SEPARATION TECHNIQUES MCQ

Paper 1

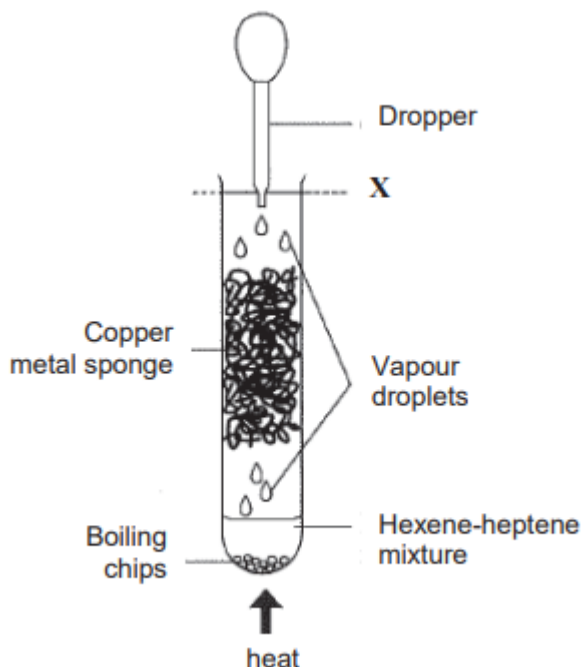
- 1 The diagram shows how to obtain pure water from seawater.
Where do water molecules lose energy?



Refer to the following to answer questions **below**.

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A small amount of mixture of 1-hexene and 1-heptene was placed in a boiling tube and gently heated to boiling in a sand bath using the following setup:



Droplets were formed and could be seen condensing on the sides of the tube. When the vapour condensation line reached the level marked **X**, the hot vapours were very slowly withdrawn and condensed by using a small dropper.

What is the purpose of the copper metal sponge?

- A Minimises contact of the mixture with air.
- B Prevents the two compounds from escaping.
- C Acts as a catalyst to speed up the reaction of the two compounds.
- D Provides a large surface area for repeated vapourisation and condensation.**

2 What process is demonstrated in this experiment?

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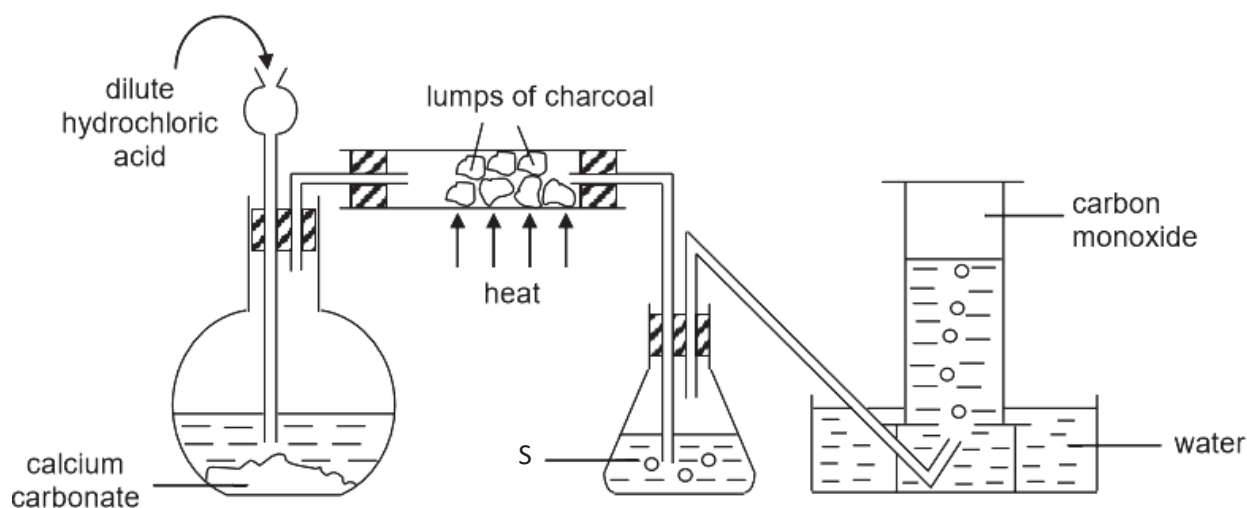
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| 1 | - 8 | 67 | insoluble |
| 2 | - 95 | 210 | soluble |

Which is the best method to separate these two substances at room temperature and pressure?

- A filtration
- B paper chromatography
- C separating funnel**
- D simple distillation

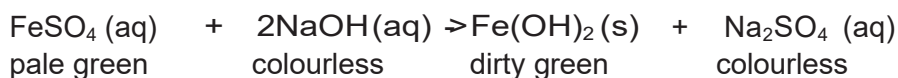
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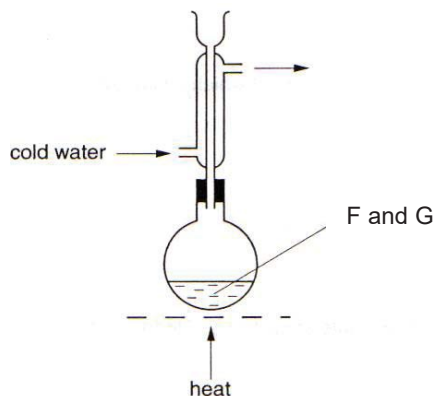
- A to remove the presence of carbon dioxide gas**
- B to remove the presence of hydrogen chloride gas
- C to remove the presence of water vapour
- D to prevent water from being drawn into the hot charcoal

- 5 The reaction between aqueous iron(II) sulfate and aqueous sodium hydroxide is shown below.



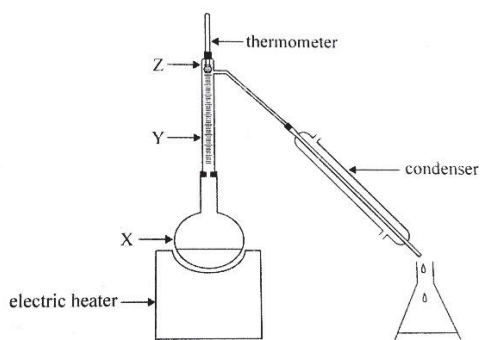
Which method could be used to separate the products?

- A crystallization
 B distillation
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- 6 The diagram shows the apparatus used for the slow reaction between liquid F (boiling point 57°C) and liquid G (boiling point 80°C).



What is the purpose of the condenser?

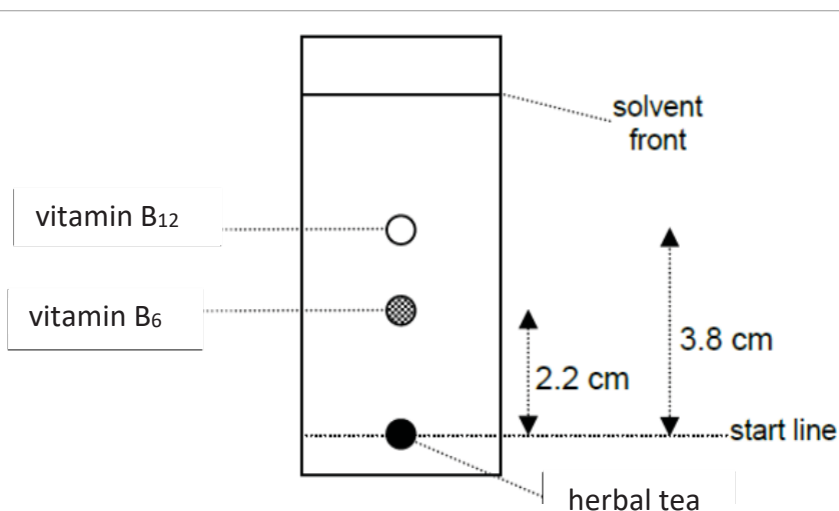
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Which of the following statements about percentage of ethanol in the vapours shown at points X, Y and Z, when the temperature is at a constant 78°C, is true?

- A The percentage of ethanol in the vapour at X is equal to 50%.
- B The percentages of ethanol in the vapour increase in order at positions X, Y and Z.**
- C The percentages of ethanol in the vapour at Y and Z are equal but greater than at X.
- D The percentages of ethanol in the vapour at X, Y and Z are equal but greater than 50%.

- 8 A sample of herbal tea containing two water- soluble vitamins was analysed during chromatography with water as a solvent. When the solvent front reached the position indicated, the chromatogram was placed under ultra-violet light. The following chromatogram was obtained.



Given that the R_f value of vitamin B₁₂ is 0.34, determine the R_f value of vitamin B₆.

- A 0.20**
- B 0.50
- C 0.56
- D 0.73

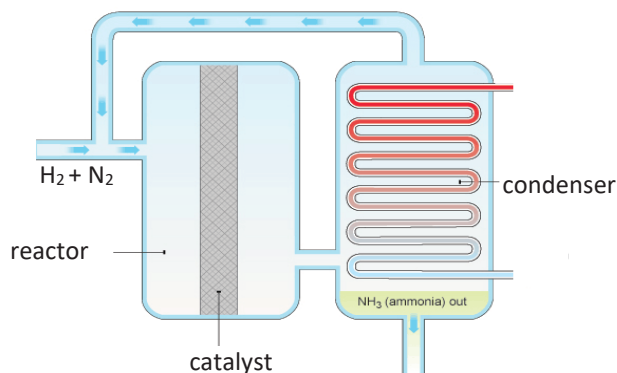
- 9 The following steps were carried out to prepare magnesium chloride.

| | |
|-----|--|
| I | Add excess magnesium carbonate to hydrochloric acid. |
| II | Heat the solution until it is saturated. |
| III | Filter , wash and dry the crystals. |

Which of the following steps should be taken to ensure that the procedure is successful in order to obtain the pure salt?

- A Filter to get rid of the excess magnesium carbonate before carrying out step II**
- B Add excess hydrochloric acid instead of magnesium carbonate in step I.
- C Evaporate the solution to dryness in step III.
- D The crystals should not be washed in step III.

- 10 Ammonia is produced by Haber process as shown in the diagram.



Which one of the following processes separates ammonia from the reaction mixture?

- A** cooling the gaseous mixture
- B** distillation of the gaseous mixture
- C** filtering out the other gases by passing through the condenser
- D** pass the gaseous mixture through fused calcium oxide

Refer to the following for questions below.

- 11 The boiling points of some elements found in a sample of air are given below.

| Element | Boiling Point/ °C |
|----------|-------------------|
| Argon | -186 |
| Helium | -269 |
| Neon | -246 |
| Nitrogen | -196 |
| Oxygen | -183 |

Which elements are gases at -190 °C?

- A** Argon and oxygen
 - B** Argon, helium and nitrogen
 - C** Helium and neon
 - D** Helium, neon and nitrogen
- 12 The sample is liquefied and separated using fractional distillation.

Which gas will be distilled off first, and which will be distilled off last?

| | First | Last |
|----------|--------|----------|
| A | Argon | Nitrogen |
| B | Helium | Oxygen |
| C | Neon | Argon |
| D | Oxygen | Neon |

- 13 A sample of sodium chloride was accidentally added to cooking oil in a beaker. Oil dissolves in ethanol.

Which of the following shows the best sequence of steps to separate and obtain a pure sample of sodium chloride from this mixture?

- A** dissolve in water → collect aqueous layer → evaporation to dryness
B dissolve in water → simple distillation → evaporation to dryness
C filtration → dissolve the residue in water → simple distillation
D filtration → wash residue with ethanol → dry residue with filter paper

- 14 The table below shows the colours and solubility of solids **W**, **X**, **Y** and **Z** in water.

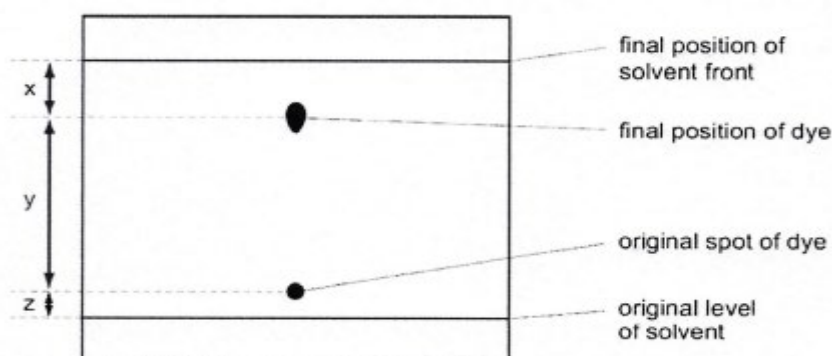
| solid | colour | solubility in water |
|----------|--------|---------------------|
| W | blue | insoluble |
| X | blue | soluble |
| Y | white | insoluble |
| Z | white | soluble |

A mixture containing two of the solids is added to excess water, stirred and filtered. At the end of the experiment, a blue filtrate and a white residue are obtained.

Which two solids are present in the mixture?

- A** **W** and **X**
B **W** and **Y**
C **X** and **Y**
D **X** and **Z**

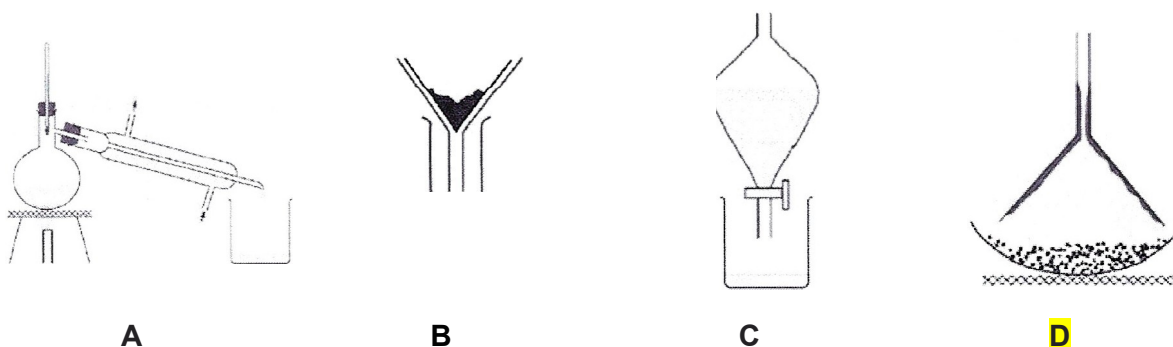
- 15 The diagram shows the chromatogram obtained by analysis of a single dye.



Which of the following gives the R_f value of the dye?

- A** $\frac{x}{x+y}$
B $\frac{y}{x+y}$
C $\frac{x}{x+y+z}$
D $\frac{y}{x+y+z}$

- 16 Which of the following apparatus should be used to separate a mixture of iodine and sodium chloride?



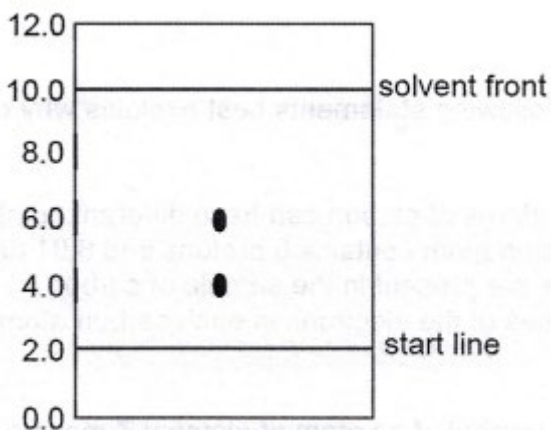
- 17 The solubilities of two samples, **A** and **B**, in dichloromethane solvent are shown below.

| Sample | Mass of sample dissolved in 100.0 g of dichloromethane at 25 °C/g |
|----------|---|
| A | 40.0 |
| B | 52.0 |

Paper chromatography was performed on a mixture of samples **A** and **B**, using dichloromethane solvent. The resulting chromatogram is shown below, with distance markings (in centimeters) on the left of the chromatogram indicating the spots' positions.

What is the R_f value of sample **B** in dichloromethane?

- A 0.60
- B 0.50**
- C 0.40
- D 0.25



- 18 Which procedure shows the best method to obtain a pure sample of silver nitrate, from a mixture of silver nitrate and silver chloride salts?

| | step 1 | step 2 | step 3 | step 4 |
|----------|--------------------|-------------------|--------------------|------------------------|
| A | dissolution | filtration | evaporation | crystallisation |
| B | dissolution | crystallisation | filtration | evaporation |
| C | dissolution | evaporation | crystallisation | filtration |
| D | filtration | dissolution | crystallisation | evaporation |

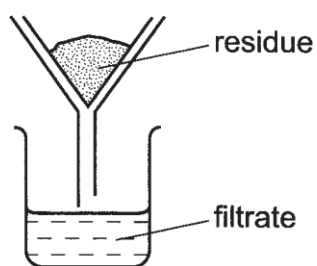
- 19 Which of the following pairs of substances can be separated by heating?

- A** ammonium chloride and potassium iodide
- B** copper (II) nitrate and potassium iodide
- C** ammonium chloride and iodine
- D** sodium chloride and copper (II) nitrate

20 The table shows the colours and the solubilities in water of four solids.

| solid | colour | solubility in water |
|-------|--------|---------------------|
| W | blue | insoluble |
| X | blue | soluble |
| Y | white | insoluble |
| Z | white | soluble |

A mixture containing two of the solids is added to excess water, stirred and filtered. A blue filtrate and a white residue are obtained.

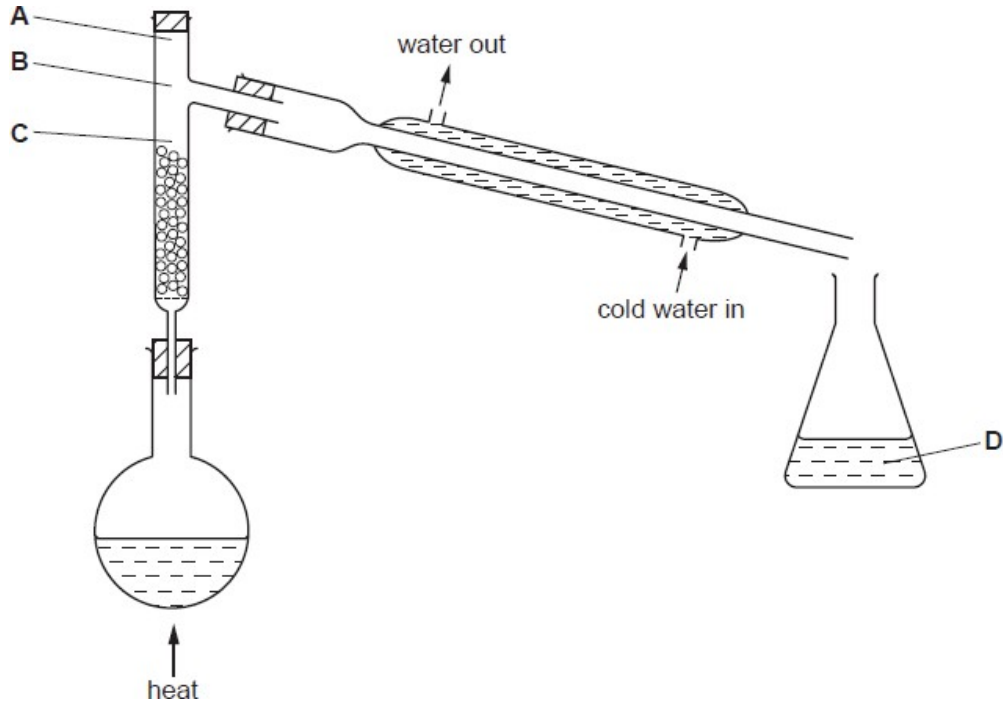


Which two solids are present in the mixture?

- A** W and X
- B** W and Y
- C** X and Y
- D** X and Z

- 21 The fractional distillation apparatus shown is being used to separate a mixture of two liquids. A thermometer is missing from the apparatus.

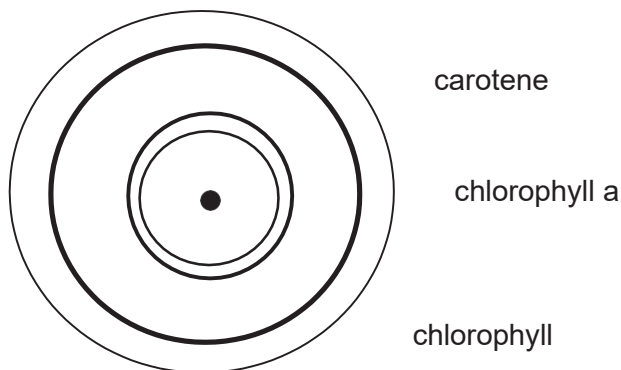
Where should the bulb of the thermometer be placed? **Answer: B**



SEPARATION TECHNIQUES STRUCTURED QUESTIONS

Paper 2 Section A

- 1 Spinach is an edible plant that has a deep green colour. The following chromatogram is obtained when water-acetone mixture is added to a drop of spinach extract in the centre of a piece of filter paper.



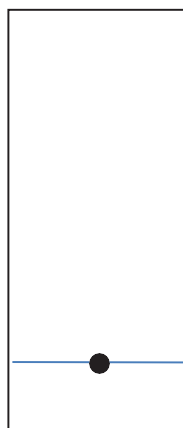
- (a) State the property which allows the components of the spinach extract to be separated using chromatography.

The components have different solubilities in the solvent.

[1]

- (b) The experiment was repeated using a typical chromatography paper as shown below.

- 3 components [1]
correct distance (relative height)
- chlorophyll b – 0.8 to 1 cm
 - chlorophyll a – 1.0 to 1.2 cm
 - carotene – 1.8 to 2.1 cm [1]



Draw and label the expected positions of the components of spinach extract on the chromatogram. [2]

- (c) State one experimental procedure that should be followed to obtain a good **separation** of the components.

The chromatography should be allowed to run until the solvent front almost reaches the top of the filter paper/
The drop of extract spotted on the filter paper should be as small as possible.
Cover with a lid to ensure consistent acetone/water com
Use a longer chromatography paper.

NB Do not award: solvent level should be below starting line/ starting line should be drawn in pencil [1]

- (d) Suggest why a water-acetone mixture is used as the solvent, instead of just a pure water or pure acetone solvent.

pure water or Spinach extract consists of substances that are soluble only in acetone - water mixture [1]

[Total: 5]

- 2 Cadmium is in the same group of the Periodic Table as zinc. Cadmium carbonate is insoluble in water and reacts in the same way as zinc carbonate with dilute acids. Cadmium sulfate is insoluble in water.

Describe how you would prepare a pure, dry sample of cadmium carbonate, starting from cadmium sulfate.

- 1 Add aqueous cadmium sulfate to aqueous sodium carbonate (or any soluble carbonate).
- 2 Filter the mixture to obtain the precipitate (cadmium carbonate).
- 3 Wash the residue.
- 4 Dry the residue (using sheets of filter paper). [4]

[Total: 9]

- 3 Aspirin is a medicine that is used as a painkiller. It is made from salicylic acid.

- (a) A student makes a sample of aspirin. She thinks it contains some impurities.

- The student tests the melting point of the sample of aspirin.

Explain how she can use the result of the test to find out whether the sample contains impurities.

If his sample is pure, the melting point should be a fixed temperature
If his sample is not pure, the aspirin should melt over a range of temperatures [2]

- The student uses chromatography to compare the sample of aspirin in (a) with pure samples of aspirin and salicylic acid.

Fig. 9.1 shows the results of the chromatogram.

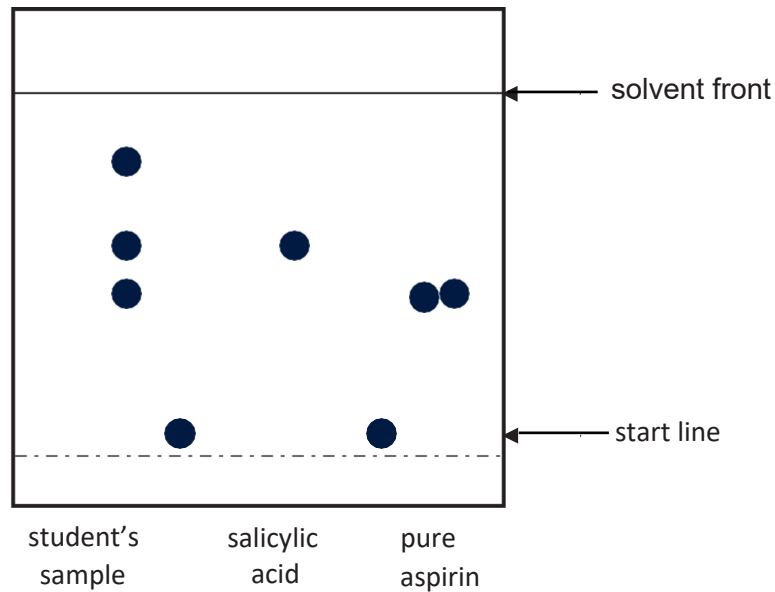


Fig. 9.1

Is the student's sample of aspirin pure? Explain your answer.

Sample is not pure.
 Sample contains **two** impurities.
 The impurities are salicylic acid and an unidentified/unknown substance [2]

- 4 (a) (iii) In another chromatography using pure samples of aspirin and salicylic acid, the solvent was allowed to travel 9 cm from the start line.

Table 9.1 shows the R_f values of pure aspirin and salicylic acid.

Table 9.1

| substance | aspirin | salicylic acid |
|-----------------------|---------|----------------|
| R _f values | 0.56 | 0.654 |

Using the information provided in Table 9.1, calculate the distance travelled by aspirin.

0.56 9 = 5.04 cm

distance =cm [1]

- (b) The student buys a few packets of aspirin tablets from a store and performs a titration using a crushed tablet and aqueous sodium hydroxide.

The formula for aspirin can be represented $\text{C}_6\text{H}_4(\text{COOH})_2$.

The equation for the reaction between aspirin and aqueous sodium hydroxide is shown below.



Table 9.2 shows the results of the student's titration.

Table 9.2

| | |
|--|--------------------------|
| concentration of aqueous NaOH used | 0.10 mol/dm ³ |
| volume of aqueous NaOH needed for neutralisation | 15.90 cm ³ |
| relative molecular mass of aspirin | 180 |

- Calculate the mass of aspirin, in mg, in one tablet. Leave your answer in 3 significant figures. (1 g = 1000 mg)

mole ratio of aspirin : NaOH = 1:1 (from equation)

$$\text{Mass of aspirin} = \left(\frac{15.90}{1000} \times 0.10\right) \times \frac{1}{1} \times 180 = 0.286 \text{ g} = \mathbf{286 \text{ mg}}$$

Award 1m for calculating number of moles of aspirin using 'M = C x V'.

Award 1m for calculating mass of aspirin using 'mass = molar mass x moles'

Award 1m for giving final answer in mg and 3 s.f

mass =g[3]

- (b) (ii) It is known that some aspirin tablets also contain citric acid. The student repeats the titration using one of these tablets.

- Explain why the mass of aspirin calculated in the second titration is different from that in (b)(i)

Citric acid (in the tablets) will also **react with / be neutralised** by sodium hydroxide during the titration.

Hence **more** sodium hydroxide would be used / the calculated mass of aspirin will be **greater** than actual. [2]

[Total: 10]

5 The table below shows some information about substances **A** to **F**.

| substances | melting point/°C | boiling point/°C | conducts electricity when solid | dissolves in water |
|------------|----------------------------------|------------------|---------------------------------|--------------------|
| A | Turns directly from solid to gas | | No | slightly |
| B | 1583 | 2862 | Yes | No |
| C | 1873 | 2230 | No | No |
| D | -114 | 78 | No | Yes |
| E | 0 | 100 | No | - |
| F | -97 | 40 | No | No |

Using the information provided, suggest the best separation technique to separate the following mixture.

- (a) A and B **Sublimation**
- (b) C and D **Filtration**
- (c) D and E **Fractional**
- (d) E and F **Using Separating Funnel** [4]

6 A series of chromatography experiments were carried out on substances **A**, **B**, **C** and **D** to determine their *R_t* values when the chromatogram was developed with different solvents. The results of the experiments are shown in Fig. 1A below.

| Substance | <i>R_t</i> value when solvent is: | | |
|-----------|---|---------|-----------|
| | Water | Ethanol | Propanone |
| A | 0.72 | 0.54 | 0.00 |
| B | 0.53 | 0.62 | 0.84 |
| C | 0.04 | 0.16 | 0.54 |
| D | 0.55 | 0.45 | 0.31 |

Fig.1A

Substances **A** to **D** are all colourless and the chromatograms are all treated with locating agents in order to determine their positions and hence *R_t* values.

(a) A student applied universal indicator as a locating agent to the chromatograms of substance **A**.

It was found that the spot for **A** was stained red for the chromatogram of **A** when developed in water, but the spot for **A** remains green when the chromatogram of **A** was developed in ethanol.

- (i) Suggest the likely pH of the spot for **A** when its chromatogram was developed in water.

pH 0/ pH 1/ pH 2

MR: A few candidates stated pH 3 and above. In addition, some candidates did not use pH as a unit when referring to the scale [1]

- (ii) Suggest and explain why the spot for **A** remains green when its chromatogram was developed in ethanol.

- Unable to dissociate to form H⁺ ions when dissolved in ethanol
- Absence of H⁺ from A results in neutral mixture

NOTE: Do NOT award 1st [B1] if candidates write "... cannot dissolve in ethanol hence unable to dissociate ..."

MR: Most candidates can recall that green refers to a neutral mixture, but were unable to link and apply this fact to the question. In addition, some candidates erroneously stated that A does not dissolve in ethanol. [2]

- (b) Explain briefly why the R_f value for **A** is 0.00 when propanone is used as the solvent.

Unable to dissolve in propanone [1]

- (c) A student carried out an experiment on an unknown sample using water as the solvent and a spot with an R_f value of 0.54 was located.

- (i) Suggest and explain which two substances could have given rise to this particular spot with an R_f value of 0.54 in the unknown sample.

- Band D
- Both have R_f values which are close/near to 0.54

NOTE: Do not award 1st [B1] if pair of "B and D" not given. Allow ECF for 2nd [B1] if idea of closeness to 0.54 is given [2]

- (ii) Describe a method to identify which of the two substances give rise to the spot with an R_f value of 0.54. Explain your reason for the method described.

- Carry out another chromatography using another named solvent (e.g. ethanol/propanone)
- Different R_f value obtained in named solvent identifies the substance as B or D

MR: Some candidates made reference to determining melting/boiling point of pure sample, but did not mention the need to reference to data to confirm identity of the substance. Separately, some candidates suggested to run the chromatography with a solvent mixture, without giving thought to the lack of data present in stem that can help complete their answer. [2]

(d) A student set up a chromatography experiment as shown in Fig. 18.

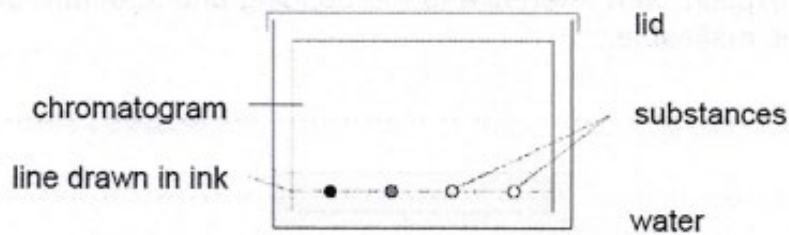


Fig.1B

Identify one error made in the set up in Fig. 1B.

Explain the effect of this error on the experiment.

ANY ONE set:

1. Error: Starting line is drawn in (pen) ink
Effect: Ink can dissolve and affect chromatogram, , --!.. CEPT OWTTE)
2. Error: Solvent level above starting line
Effect: All substances can dissolve into solvent OR No clear separation can take place (ACCEPT OWTTE:)

NOTE: 1s t [B1] for correct., Identified error 2nd [B1] can only be awarded if effect follows correct error

MR: Question was generally well done.

[2]

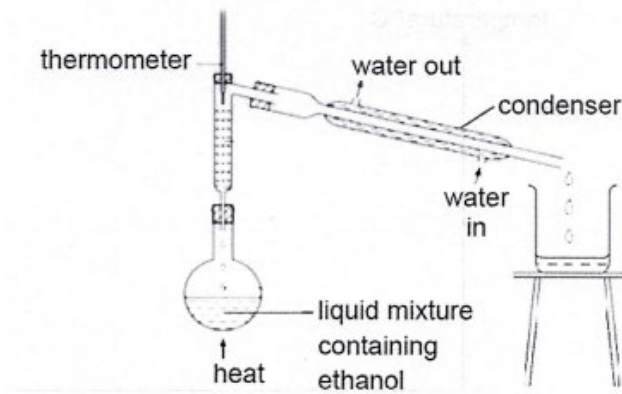
[Total: 10 marks]

7 The physical properties of five substances are shown in the table below. One of these substances is ethanol, while the other four unknown substances are labelled as **W**, **X**, **Y** and **Z**.

| substance | melting point/°C | boiling point/°C | soluble in ethanol | conducts electricity in solid state |
|-----------|------------------|------------------|--------------------|-------------------------------------|
| w | -98 | 65 | yes | no |
| X | -30 | 174 | n o | no |
| Y | 153 | 310 | yes | no |
| Z | 842 | 1484 | no | yes |
| ethanol | -114 | 78 | N.A. | no |

(a) Samples of **W**, **X**, **Y** and **Z** were **individually** mixed with ethanol, and stored in four separate containers at room temperature.

One of the four unknown substances shown in the table above can be separated from ethanol using the set-up shown below.



(i) Name the technique used to separate the liquids in the mixture.

Fractional distillation

Do not accept distillation [1]

(ii) State the purpose of the condenser in the set-up shown above.

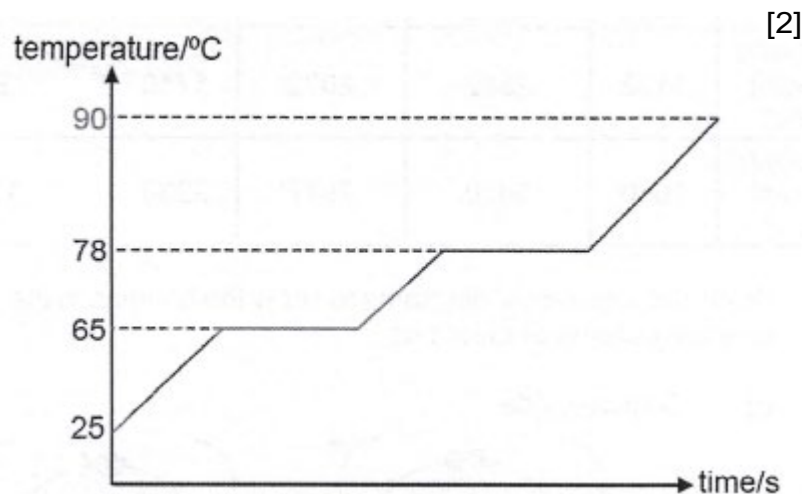
To provide a cool surface for the vapour to condense [1]

(iii) By making use of the information provided in the table, state which substance, when mixed with ethanol, can be separated using the set-up shown above. Explain your answer.

W [1]

W is a liquid which is miscible in ethanol and has a different boiling point from ethanol. [2]

(iv) Using the axes provided, sketch how the temperature indicated by the thermometer varies with time when the mixture in (a)(iii) is heated from 25 °C to 90 °C. Label your axes with relevant information from the table above.



Two flat regions corresponding to boiling in of fluids - [1]

Temperature axis lab ed with all necessary temperatures - [1]

- (v) Apart from the substance in (a)(iii), suggest appropriate separation methods to obtain the three remaining unknown substances from ethanol.

| substance being mixed with ethanol | method to obtain substance from ethanol mixture |
|------------------------------------|---|
| X | Separating funnel |
| Y | Crystallisation/evaporation to dryness |
| Z | Filtration |

[3]

- (b) Having carefully studied the information in the table, Kent, a Chemistry student, claimed that substance **Z** is a metal.

Using information from the table, state a piece of evidence which would **best** support Kent's claim.

With reference to the structure and bonding in metals, explain how this piece of evidence suggests that substance **Z** is a metal.

Evidence **Z conducts electricity in the solid state.** [1]

Explanation

Z contains ions which are surrounded by a sea of delocalised electrons. [1]

The delocalised electrons are able to move freely and act as charge carriers even in solid state, allowing for the conduction of electricity. [1]

[3]

[Total: 12]
