# BioMedical Admissions Test (BMAT)

## Section 2: Chemistry

### Questions by Topic

### C8 - Separation Techniques I

# C8: Separation Techniques I - Question by Topic

*(Mark Scheme and explanations at the end)*

**1** Lauren carried out an experiment in the lab which produced a metal compound. She performed a test to see what metal ions were present. First she cleaned a wire loop with hydrochloric acid followed by distilled water, and then she placed it into the metal compound to get a sample. Lauren then put the wire into the blue part of the flame of a Bunsen Burner, and the flame turned lilac.

Which of the following metal ions must have been present?

**A** Potassium ions, $K^+$
**B** Calcium ions, $Ca^{2+}$
**C** Lithium ions, $Li^+$
**D** Barium ions, $Ba^{2+}$
**E** Sodium ions, $Na^+$

**2** The following table shows 3 common gases, the test for the gases, and the observation that can be made if the gas is present.

| Gas | Test | Observation |
|---|---|---|
| **1** | Put a glowing splint in the test-tube containing the gas. | The splint relights. |
| **2** | Light a splint and place it inside the test-tube containing the gas. | A squeaky pop sound can be heard. |
| **3** | Place a piece of damp litmus paper into a test-tube containing the gas. | Litmus paper turns white. |

Which of the following options correctly labels the gases 1, 2 and 3?

**A** 1 = oxygen, 2 = chlorine, 3 = hydrogen
**B** 1 = chlorine, 2 = hydrogen, 3 = oxygen
**C** 1 = oxygen, 2 = hydrogen, 3 = chlorine
**D** 1 = chlorine, 2 = oxygen, 3 = hydrogen
**E** 1 = hydrogen, 2 = chlorine, 3 = oxygen
**F** 1 = hydrogen, 2 = oxygen, 3 = chlorine.

**3** A student performed paper chromatography on 2 chemicals. Looking at the chromatogram, she observed that one chemical travelled 2cm further up the paper than the other. The following statements refer to the chemical that travelled further.

**1** This chemical spent more time in the mobile phase relative to the stationary phase.
**2** This chemical is likely less soluble in the solvent.
**3** This chemical is likely less attracted to the paper.

Which of the above statements are correct?

**A** 1, 2 and 3
**B** 1 and 2
**C** 2 and 3
**D** 1 and 3
**E** 1 only
**F** 2 only
**G** 3 only

**4** In a titration experiment, Ali begins with $20cm^3$ of potassium hydroxide. The potassium hydroxide has a concentration of 0.1 moles per $dm^3$. He discovers that it takes $25cm^3$ of nitric acid to neutralise all of the potassium hydroxide in the flask.

What is the concentration of the nitric acid that Ali used, in mol $dm^{-3}$ ?

**A** 0.8 moles per $dm^3$
**B** 0.08 moles per $dm^3$
**C** 0.064 moles per $dm^3$
**D** 0.64 moles per $dm^3$
**E** 0.1 moles per $dm^3$
**F** 0.01 moles per $dm^3$

**5** The following statements refer to the process of electrolysis.

**1** Electrolysis is used to break apart solid ionic compounds.
**2** The electrolyte is responsible for conducting electricity in electrolysis.
**3** Electrolytes are made up of free ions - these can be molten (l) or dissolved in solution (aq).
**4** Ions at the negative electrode lose electrons, and these flow to the positive electrode where they are accepted.
**5** Oxidation and reduction, sometimes, but not always, occur in electrolysis.

Which of the above statements are incorrect about electrolysis?

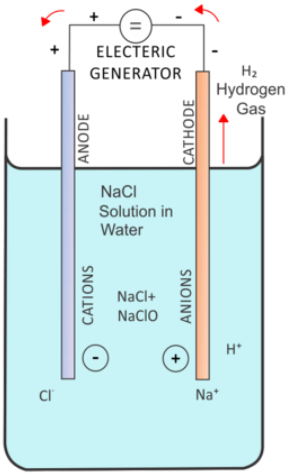
**A** 1, 2 and 5
**B** 1, 4 and 5
**C** 2, 3 and 5
**D** 2, 4 and 5
**E** 1 and 3 only
**F** 1 and 4 only
**G** 2 and 3 only
**H** 2 and 4 only

**6** Aspirin, acetylsalicylic acid, is a weak acid. Kenny performed a titration to find out how much sodium hydroxide was needed to neutralise a solution of aspirin. He found that he needed 10.2 $cm^3$ of 3 $g/dm^3$ NaOH, to neutralise a solution which contained 0.24g of impure aspirin dissolved in 20 $cm^3$ of ethanol. The concentration of the aspirin solution can be calculated using this formula:
Concentration = 4.5 x (concentration of NaOH x volume of NaOH) / volume of aspirin solution
aspirin solution

What is the percentage purity of Kenny's aspirin?

**A** 83.33%
**B** 57.38%
**C** 33.04%
**D** 12.75%

**7** The following diagram shows electrolysis of sodium chloride after it has been dissolved in water.




**1** During electrolysis of sodium chloride, 3 products are produced: hydrogen, chlorine, and sodium hydroxide.
**2** Chlorine ions are attracted to the negative electrode.
**3** Chlorine is produced at the positive electrode.
**4** Hydrogen ions accept electrons and will get reduced during this electrolysis.

Which of the above statements are correct concerning the electrolysis of sodium chloride?

**A** 1, 2, 3 and 4
**B** 1, 2 and 3
**C** 2, 3 and 4
**D** 1, 3 and 4
**E** 2 and 4
**F** 1 and 2
**G** 1 and 4

**8** The following statements refer to ways to separate substances.

**1** Miscible liquids are best separated using a separating funnel.
**2** Oil and water are immiscible.
**3** Fractional distillation and paper chromatography can separate miscible liquids.
**4** When separating a soluble and insoluble solid, after dissolving the mixture in a beaker and filtering the mixture, you are always left with the pure soluble solid only in the beaker.

Which of the above statements are false concerning separating techniques?

**A** 1, 2, 3, 4 and 5
**B** 1, 2, and 3
**C** 2, 3 and 4
**D** 2, 4 and 5
**E** 4 and 5
**F** 1 and 4
**G** 3 and 5

**9** Electroplating is a way of coating metals.

Which of the following is the best description of how electroplating works using electrolysis?

**A** Metal ions in a solution will flow towards the negative electrode where they lose their charge and get deposited onto the metal that you want to be plated. The negative electrode will lose mass.
**B** Metal ions in a solution will flow towards the positive electrode where they lose their charge and get deposited onto the metal that you want to be plated. The positive electrode will lose mass.
**C** Metal ions in a solution will flow towards the negative electrode where they lose their charge and get deposited onto the metal that you want to be plated. The negative electrode will gain mass.
**D** Metal ions in a solution will flow towards the positive electrode where they lose their charge and get deposited onto the metal that you want to be plated. The positive electrode will gain mass.

**10** The following statements refer to chromatography.

**1** In both thin layer chromatography and paper chromatography, paper is the stationary phase.
**2** The Rf value is: distance travelled by solvent / distance travelled by solute
**3** SRMs (standard reference materials) can help to identify unknown substances.
**4** If 2 samples of substances get the same Rf values on a chromatogram, this proves that they must be the same substance.

Which of the above statements are incorrect?

**A** 1, 2, 3 and 4
**B** 1, 2 and 4
**C** 2, 3 and 4
**D** 1 and 4
**E** 2 and 3
**F** 3 and 4

# Answers and Explanations

**1** **The answer is A**

A flame changes colour to **lilac** when **potassium ions** come into contact with it. This suggests that the metal compound produced in Laura's experiment contained potassium.

***Exam Tip*** - Make sure you know the colour changes for the 5 common metal ions in the flame test:

| Metal ion | Flame colour |
|---|---|
| Potassium ions, $K^+$ | Lilac |
| Calcium ions, $Ca^{2+}$ | Red |
| Lithium ions, $Li^+$ | Crimson |
| Barium ions, $Ba^{2+}$ | Green |
| Sodium ions, $Na^+$ | Yellow |

**2** **The answer is C**

Below is the correctly completed table.

| Gas | Test | Observation |
|---|---|---|
| **Oxygen** | Put a glowing splint in the test-tube containing the gas. | The splint relights. |
| **Hydrogen** | Light a splint and place it inside the test-tube containing the gas. | A squeaky pop sound can be heard. |
| **Chlorine** | Place a piece of damp litmus paper into a test-tube containing the gas. | Litmus paper turns white. |

***Exam Tip*** - Note that sometimes, in the chlorine test, the damp litmus paper **momentarily turns red** before becoming **bleached** to white, because chlorine solution is **acidic!** Make sure the BMAT doesn't catch you out on this point.

**3** **The answer is D**

**2** is incorrect - the chemical that travelled further is likely to have had a **higher solubility for the solvent!**

If this question was asking about the chemical that travelled a shorter distance up the paper, we would presume that this chemical had a lower solubility in the solvent, a higher attraction to the paper, and it spent more time in the stationary than the mobile phase.

***Exam Tip*** - Remember that how long a molecule spends in the stationary and mobile phases depends on 2 things:

1. How **soluble** the substance is in the **solvent**
2. How **attracted** the substance is to the **paper**

**4** **The answer is B**

There are 3 key steps to answering titration questions like these:

1. Calculate the number of moles of the substance for which you know the volume and concentration (in this case, potassium hydroxide)
2. Write the balanced equation for the neutralisation reaction
3. Calculate the concentration of the substance in question (in this case, nitric acid)

So here is how you would work out the answer to this question.

1. Use the formula **no of moles = concentration x volume** to find the no of moles of potassium hydroxide.
   =0.1 moles per $dm^3$ x $(20/1000)dm^3$
   =0.002 moles of KOH

2. The **balanced equation** for this neutralisation reaction is:
   $KOH + HNO_3 \rightarrow H_2O + KNO_3$
   This shows that the **ratio of moles** of acid (nitric acid) to base (potassium hydroxide) is **1:1**.

Therefore, if there were 0.002 moles of KOH, then there were 0.002 moles of $HNO_3$.

3. Reusing the same formula from step 1, we can now calculate the concentration of nitric acid.
**Concentration = no of moles / volume**
= 0.002 / (25/1000)$dm^3$
= 0.08 moles per $dm^3$ = concentration of nitric acid.

**5** **The answer is B**

**1** is incorrect - the ions need to be **free to move** for electrolysis to work; they are in a **fixed position in solid** ionic compounds. Electrolysis only works on **ionic compounds** which are **aqueous (in solution) or liquid (molten)**.

**4** is incorrect - electrons flow in the **opposite direction** - they are lost from ions at the positive electrode and flow towards the negative electrode, where the electrons are accepted by other ions.

**5** is incorrect - **oxidation and reduction are central features of electrolysis**. They are **always** involved in electrolysis. Ions are constantly gaining and losing electrons at either electrode.

**6** **The answer is B**

To answer this question, you need to work out 3 properties of the aspirin, in this order:

1. **Concentration** of the aspirin solution
2. **Mass** of the aspirin
3. **Purity** of the aspirin

Let's work through the question step by step to see how we come to **B,** 57.38%.

**1. Concentration of aspirin solution = 4.5 x (concentration of NaOH x volume of NaOH) / volume of aspirin solution**

*(the value 4.5 is given in the formula for this particular neutralisation reaction between the acid aspirin and the alkali sodium hydroxide. Do not worry about calculating this yourself for the BMAT. It will most likely be given as there is already a lot of calculation work required in this question.)
=4.5 x (3 x(10.2/1000))/ (20/1000)
= 6.885g/$dm^3$
**(the volumes are divided by 1000 to get them from $cm^3$ into $dm^3$. This is because 1$dm^3$ is the same as1000$cm^3$.)

2. **Mass of aspirin = concentration x volume**
   = 6.885 x (20/1000)
   = 0.1377g
   Therefore, of the sample of 0.24g of impure aspirin, 0.1377g was aspirin.
3. **% Purity of aspirin = (calculated mass of substance/mass of substance at start) x100**
   =0.1377/0.24 x 100 = 57.375%.
   The percentage purity of the aspirin is **57.38%.**

**7** **The answer is D**

Statements **1**, **3** and **4** are correct.

**2** is incorrect - chlorine ions themselves are negative, which makes them attracted to the **positive electrode.** Here, 2 Cl- ions will **lose their electrons** to form 1 chlorine atom. They therefore get **oxidised** at the positive electrode.

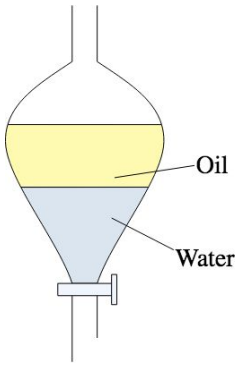
Hydrogen ions, on the other hand, are positive, and so they will **flow towards the negative electrode**, where they **gain 2 electrons** to form 1 hydrogen atom. They get **reduced** (as **4** outlines).

**8** **The answer is F**

Only statements **1** and **4** are incorrect.

**1** is incorrect - miscible liquids (ones that mix together) require more complex separating techniques such as **fractional distillation** and **paper chromatography.** Immiscible liquids, on the other hand, can easily be separated using a separating funnel.

***Exam Tip*** 1- Oil and water is a prototypical immiscible mixture. You might already know from your BMAT biology learning that oil and water do not mix because oil is non-polar and hydrophobic ("water-fearing"). Since oil is less dense than water, oil will float on top of the water layer. This makes it easy to open the stopper in a separating funnel and allow the water to run off, leaving the oil left when you close the stopper.




**4** is incorrect - when separating a soluble and insoluble solid, after dissolving the mixture in a beaker and filtering the mixture, you are left with a solution that contains both **solvent** and the soluble solid. You still need to **heat the solution** so that all of the **solvent evaporates.** You will then be left with crystals **of the pure, soluble solid**.

***Exam Tip*** 2- It may be helpful to remember 3 steps to separating soluble and insoluble solids:

1. Dissolve
2. Filter
3. Crystallise

DFC: Don't Forget the Crystals!

**9** **The answer is C**

In electroplating, the **metal** that you wish **to be coated** is always the **negative electrode**. It usually gets coated with a pure metal e.g. silver, and this is the **positive electrode** (try and remember pure, for positive!) Ions from this pure plating metal will then flow towards the negative electrode (the metal you want to coat). Here they will **lose their charge** and get **deposited** onto that metal, coating it.

The positive electrode **loses mass**, because its metal ions will go into the solution, whereas the negative electrode will **gain mass**.

***Exam Tip*** - In order to carry out electroplating by electrolysis, you need a metal that you wish to coat, a pure metal to coat it with, and a solution that contains ions of the plating metal. This table shows 2 common examples of 3 components used together for electroplating.

| Metal to be coated (negative electrode) | Pure metal used as coat (positive electrode) | Solution containing pure metal ions |
|---|---|---|
| Iron | Copper | Copper sulfate |
| Brass | Silver | Silver nitrate |

**10** **The answer is B**

**1** is incorrect - thin layer chromatography and paper chromatography both have the same **same mobile phase** (usually a solvent like ethanol), but they **differ in their stationary phase.**
The stationary phase for paper chromatography is paper, whereas the stationary phase for thin layer chromatography is a **thin layer of a solid** such as silica gel.

**2** is incorrect - the correct formula for calculating Rf values is actually: **distance travelled by solute/ distance travelled by solvent**
Think about it: the solvent will always travel further than the solute, so this larger number should be on the bottom.

**4** is incorrect - samples with the same Rf value **may** be the same substance, but **not necessarily**. Another point that helps to identify 2 of the same substance in chromatography is that the same substances will also produce the **same amount of spots**, and these spots will be the **same colour**.