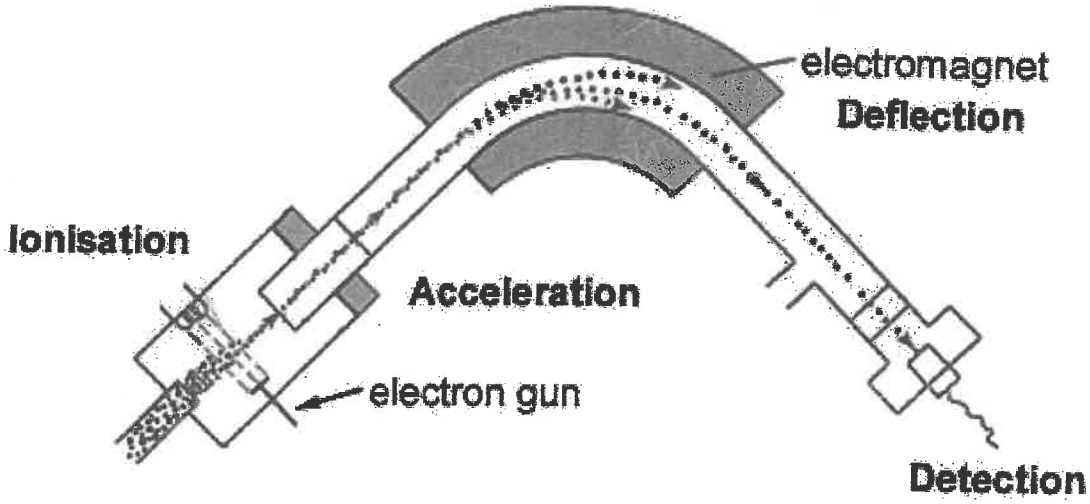
Name SOLUTION.

Extended response

Mass Spectroscopy and Separation

/45

Shown below is a simplified image of a mass spectrometer.



Answer the questions below outlining the processes that occur in each section of the mass spectrometer.

1. Explain how ions are produced in the ionization chamber? Use a simple diagram to help explain you answer. (2 marks)

Vapourised atoms (molecules) are struck by electrons from the electron gun removing e^-s causing them to become (positive) ions.

2. What is the function of the deflection chamber in the mass spectrometer? (1 mark)

To separate the isotopes/ions of diff. mass (with different mass:charge ratios)

3. Explain why the mass spectrometry process is conducted in a vacuum. (2 marks)

The ions produced would collide with air particles and not reach the detectors

4. Describe the measurement/s that can be detected and recorded by the mass spectrometer. (2 marks)

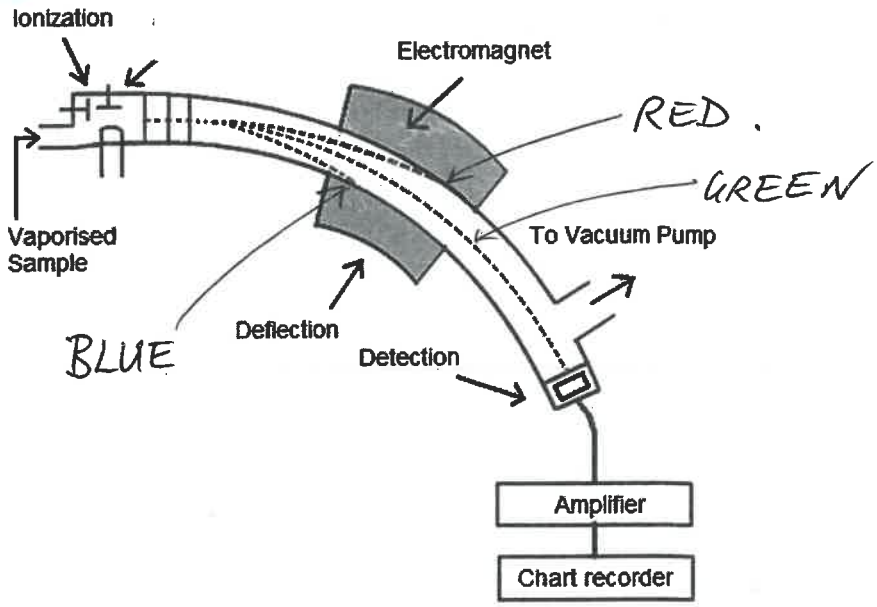
(mass : charge ratio) and the number of each [mass – ½ mark] in the sample.

5. Complete the table below using the information provided to indicate numbers of subatomic particles found in the following species. (7 marks)

Species name	Species symbol	Atomic number	Number of neutrons	Number of electrons
Chlorine – 37 atom	$^{37}_{17}Cl$	17	20	17
Potassium – 39 (atom)	$^{39}_{19}K$	19	40	19
Boron – 11 (atom)	^{11}B	5	6	5
Neon – 20 atom	^{20}Ne	10	10	10
Iron III ion	Fe^{3+}	26	—	23
Sodium ion	Na^{+}	11	—	10
Oxide (ion)	O^{2-}	8	8	10

* optional.

Consider the diagram below showing three different particle types passing through the electromagnet in the deflection chamber. Each particle type is shown in a different colour.

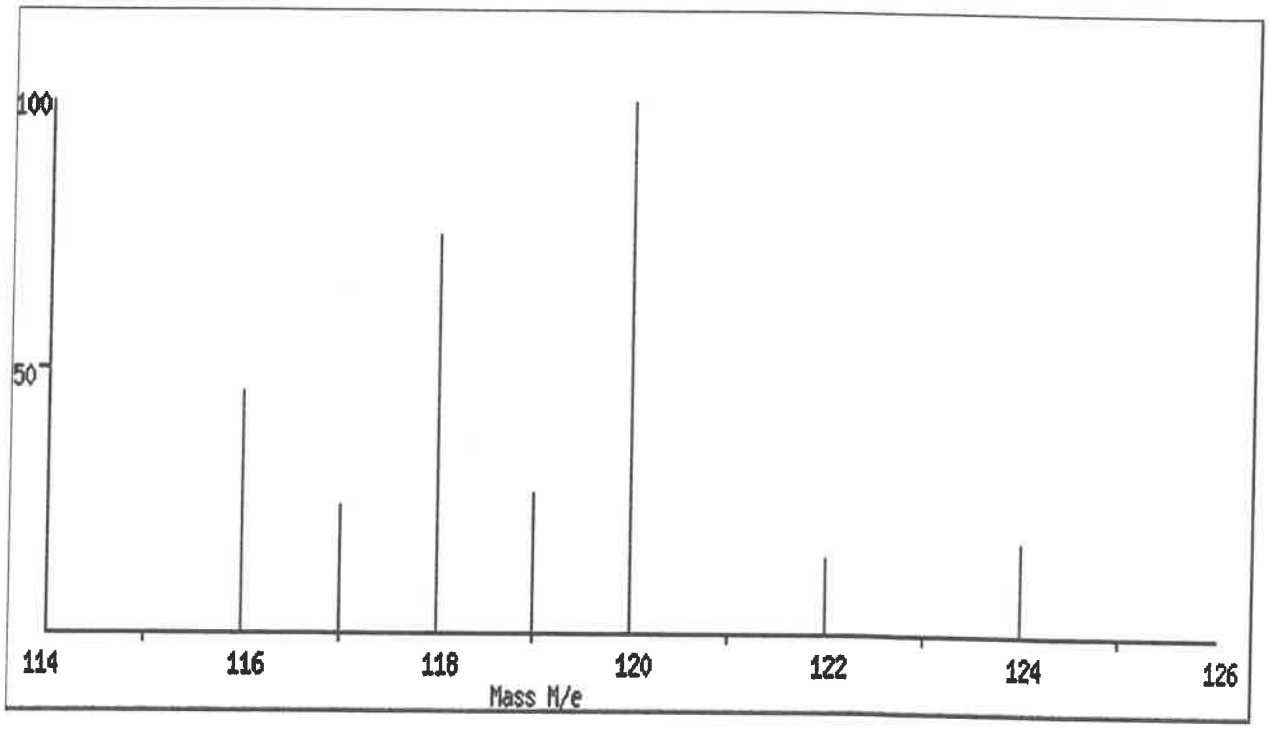


6. Which of the particles shown (red, green or blue) would be the heaviest? Explain your answer. (2 marks)

RED. It is deflected the least. The heavier an isotope the more force required to make it change direction. (+ all ions of the same charge experience same force)

(Assumes all isotopes have same speed and charge)

7. A sample of tin is injected and analysed by mass spectroscopy. The mass spectrum obtained is shown below.



Create a **table** to show the *isotopes present* and their *relative abundance.*

(2 marks)

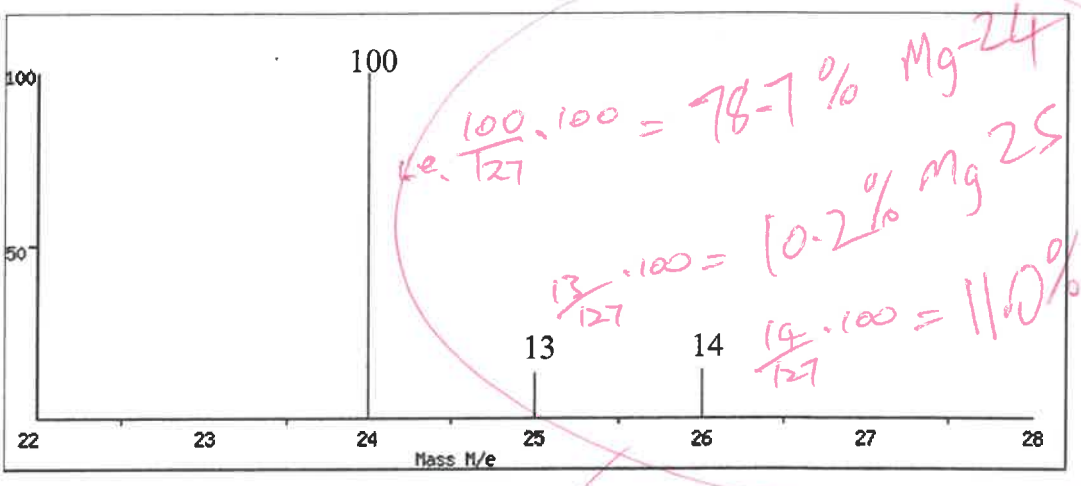
Isotopes of Tin

Isotope.	Length of line (mm)	Relative Abundance	
		Fraction	≈ %
116	32.0	32/213	15%
117	17.0	17/213	8%
118	53.0	53/213	25%
119	18.5	18.5/213	9%
120	70.0	70/213	33%
122	10.0	10/213	4.7%
124	12.5mm	12.5/213	5.9%

(SAMPLE) TOTAL = 213mm

(must show % for full mks)

8. The mass spectrum obtained from a sample of magnesium is shown below.



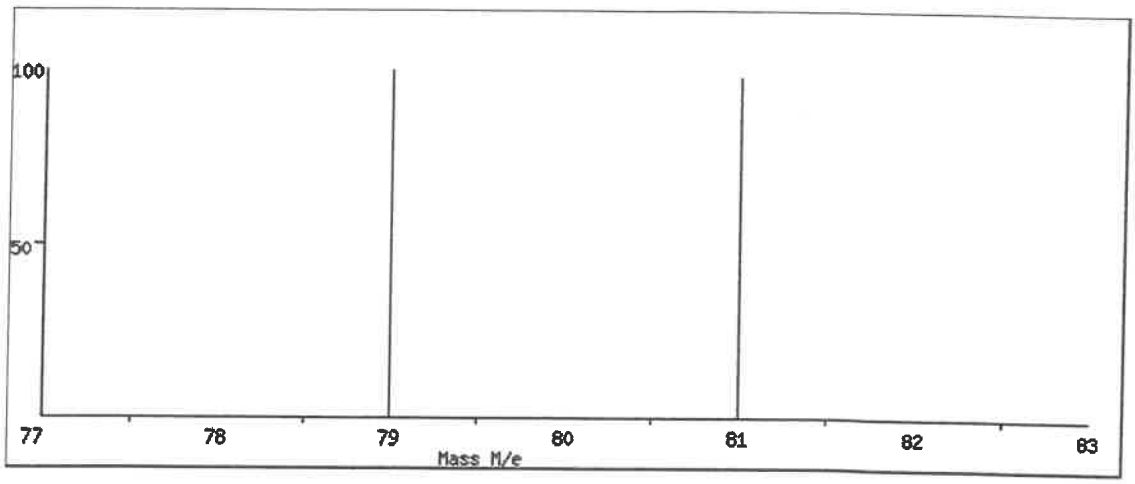
The numbers assigned to each peak indicate the relative abundance of that isotope. Use *this* information to determine the relative atomic mass of Magnesium in this sample. (3 marks)

$$M_{RAM} = \frac{(78.7 \times 24) + (10.2 \times 25) + (11.0 \times 26)}{100}$$

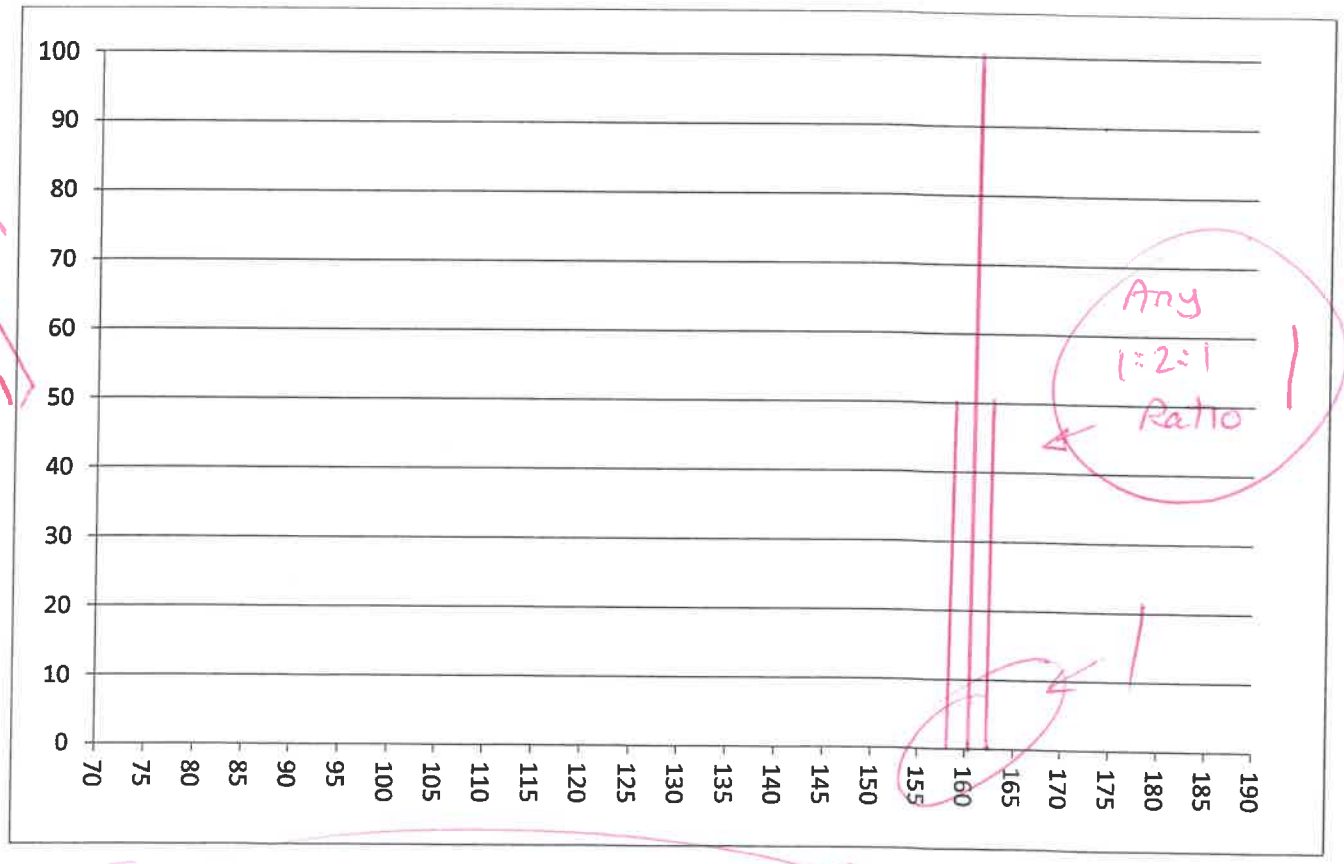
$$= 24.3$$

ie. The R.A.M. of Mg is 24.3.

9. Bromine atoms exist as 2 isotopes with atomic masses of 79 and 81 a.m.u. as shown in the spectrum below. Each of the isotopes occurs with equal abundance.



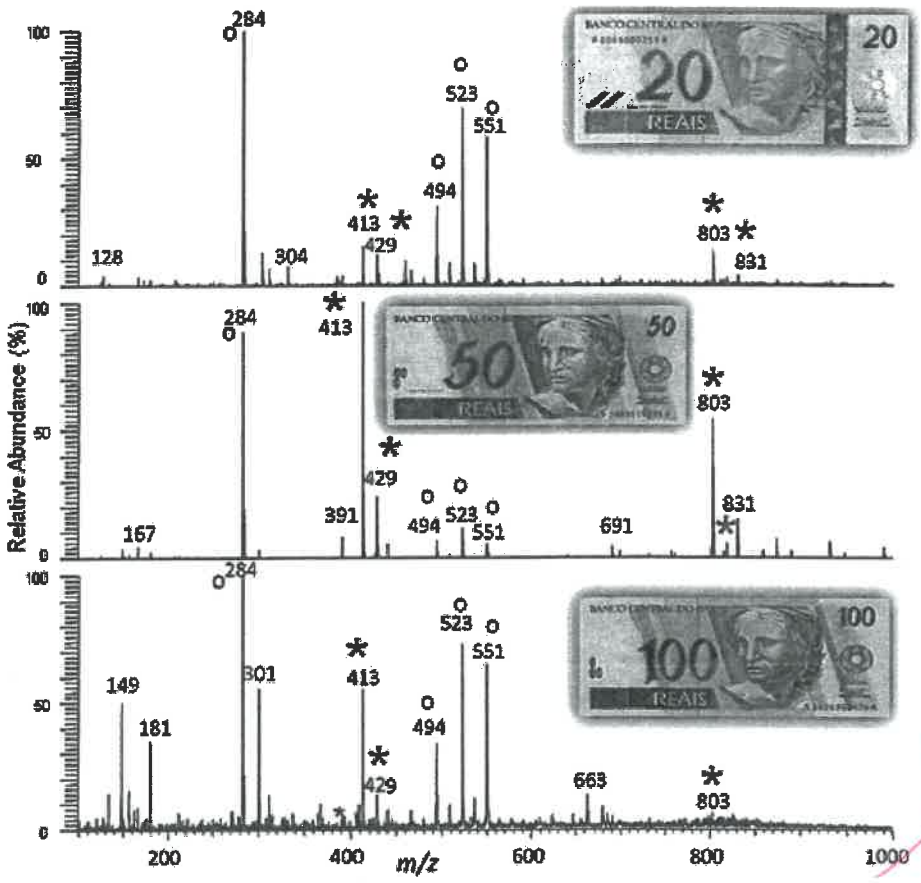
If mass spectrometry was carried out on a sample of bromine vapour, a diatomic molecule with the formula Br_2, **sketch** the spectrum you would most likely attain from this sample. (4 marks)



10. Banknote counterfeiting is a growing problem for fraud investigators across the globe and criminals involved in this highly profitable system are constantly developing their techniques to stay one step ahead of the authorities and their forensic detection methods. Now, researchers in Brazil and the US have taken a mass spectrometric approach that can produce a near-instantaneous chemical profile of a banknote to check against database entries and spot counterfeit notes very quickly.

The team first tested the techniques using genuine Brazilian banknotes and compared the fingerprints with "homemade" banknotes produced on a readily available paper using different types of computer printer.

Genuine banknotes produced the spectra shown below:



Explain how such spectra could be used to successfully detect forgeries

(2 marks)

Original banknotes would have known dyes (chemical colouring compounds) with a known signature i.e. spectrum shown isotope + rel. abundance

Notes made with any other dyes would produce different spectra and hence would be identified as forged.

11. Choose the word or phrase from the left hand column that **best** suits the description/definition in the right hand column.

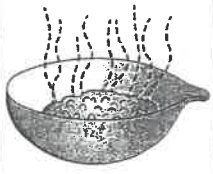
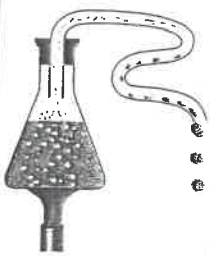
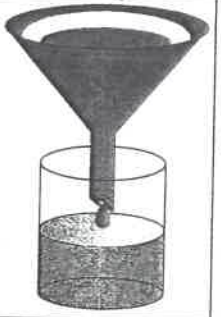
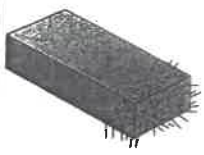
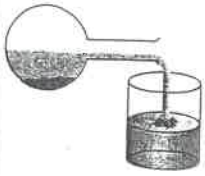
Write the lower case letter next to the chosen description/definition. (5 marks)

(½ each)

a chemical change	
b chemical property	
c compound	
d distillate	
e distillation	
f electrostatic attraction	
g element	
h filtrate	
i filtration	
j fractional distillation	
k heterogeneous mixture	
l homogeneous mixture	
m magnetic separation	
n material	
o matter	
p mixture	
q physical change	
r physical property	
s residue	
t separating funnel	
u sieving	
v solute	
w solution	
x solvent	
y substance	
z vaporisation	

A homogeneous mixture ...(an example of..)	w
B change in the composition of a substance, giving a new substance	a
C change not involving the chemical composition of a substance	q
E dissolved substance	v
G having a non-uniform composition	k
J liquid or solution that passes through filter paper during filtration	h
N pure substance made up of only one type of atom	g
P separating an undissolved solid from a liquid	i
S solid remaining in the filter paper after filtration	s
X technique for retrieving the liquid component of a solution	e

12. Identify each of the separation techniques shown below. (3 marks) (½ each)

					
evaporation	distillation	filtration	magnetic (..separation)	decanting	seiving

13. Circle items on the list below that are physical properties of substances. (2 marks) (-½ for each error or omission)

- strength
- density
- colour
- reaction with acids
- conductivity
- reaction with oxygen
- state
- decomposition by heat
- solubility
- melting point
- reaction with bases
- boiling point

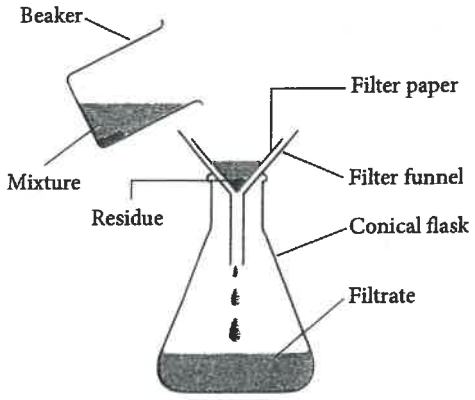
14. Explain how the apparatus in each diagram results in the separation of substances in a mixture. (8 marks)

≠ description ≠ ½ mk (each) for descriptions.

½ for the diff in physical prop/s.

Particle size →

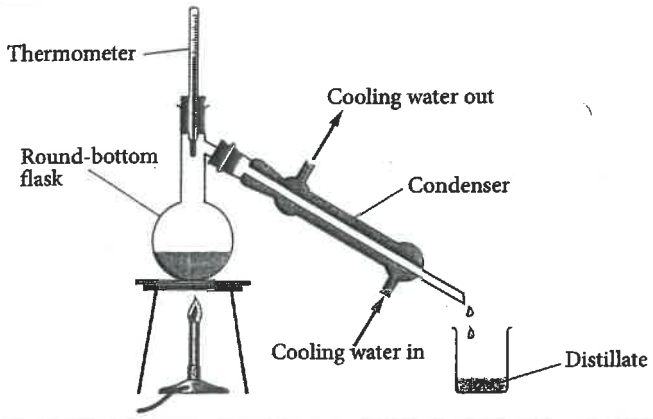
a



The residue particles are too big to pass through the paper while the much smaller water/solution particles can pass through into the flask.

b

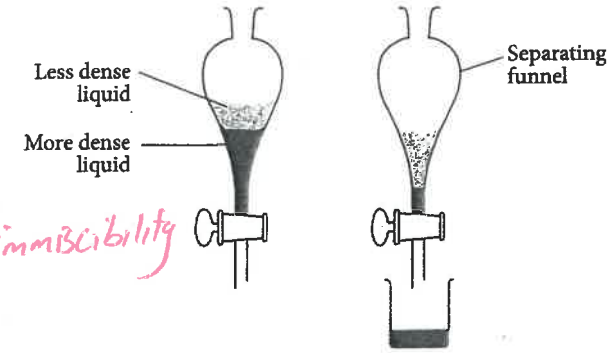
Boiling pts →



The substances in the round-bottom flask have different boiling pts. That with the lowest b.p evaporates off first leaving the higher b.p substance behind.

c

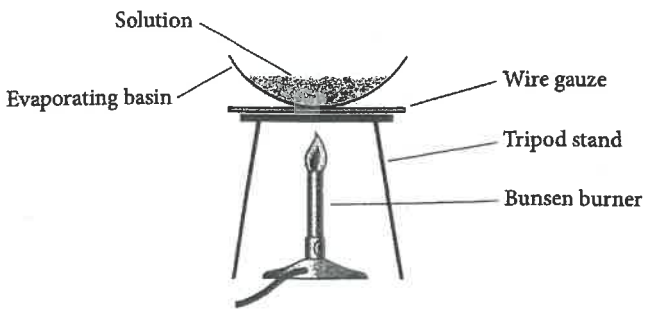
Density and solubility/immiscibility →



The more dense liquid of the immiscible pair sinks to the bottom while the less dense liquid floats on top.

d

Boiling Points →



The solvent with the lower boiling point is rapidly evaporated. The solute with much higher (melting and) boiling point remains (... the remaining solution becomes saturated + solute crystallises out...)