1. Which element has the highest first ionization energy?
   a) Sulfur
   b) Phosphorus
   c) Chlorine
   d) Argon

First ionization energy increases across a period (left → right) due to increasing nuclear charge, and decreases down a group as the distance between the valence electrons and nucleus increases. Among sulfur, phosphorus, chlorine, and argon (all in Period 3), argon is a noble gas with a full valence shell, making it the hardest to remove an electron from.

2. Using electrostatic repulsion, which species would be expected to have the largest radius?
   a) Na
   b) Na^+
   c) Cl
   d) Cl^-

Cations (Na^+) are smaller than their neutral atoms. Anions (Cl^-) are larger than their neutral atoms. Atomic radius decreases across a period. Na^+ is very small (lost an electron) . Na > Cl (neutral comparison across period) . Cl^- is largest because it has extra electron repulsion

3. Which species has the smallest electronegativity difference with hydrogen?
   a) Fluorine
   b) Chlorine
   c) Oxygen
   d) Nitrogen

Using the periodic table given in the data book students should be able to arrive at the answer that N has the smallest difference in electronegativity when compared with hydrogen. Electronegativity of each element is given in the periodic table.

4. Which option below has the elements in order of increasing reactivity from left to right, where left is the lowest and right has the highest reactivity.

   a) Be, Mg, Sr, Ra
   b) Cs, Rb, Na, Li
   c) Ra, Ba, Ca, Be
   d) K, Ca, Mg, Be

Reactivity for group 1 and group 2 metals increases down the group because valence electrons are further from the nucleus, therefore, easier to lose electrons (lower ionization energy)
Correct increasing order: Be < Mg < Sr < Ra

5. Consider the subshell electronic configurations of the neutral elements shown below?
   i. $1s^2,\ 2s^2,\ 2p^6,\ 3s^2,\ 3p^6,\ 3d^5,\ 4s^1$
   ii. $1s^2,\ 2s^2,\ 2p^6,\ 3s^2,\ 3p^6,\ 3d^{10},\ 4s^1$
   iii. $1s^2,\ 2s^2,\ 2p^6,\ 3s^1,\ 3p^2$
   iv. $1s^2,\ 2s^2,\ 2p^6,\ 3s^2,\ 3p^6,\ 3d^6,\ 4s^2$
   v. $1s^2,\ 2s^2,\ 2p^6,\ 3s^2,\ 3p^6,\ 3d^6,\ 4s^1,\ 4p^1$

Which of the above are in an excited state not at ground state?

a) i, ii and iv only
b) i, ii, iii, iv and v
c) i, ii and v only
d) v and iii only

$1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^5$, $4s^1$ This is chromium (Cr) known exception where half full subshells are more table than partly filled. Same goes for copper where $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^{10}$, $4s^1$. A full d subshell and half filled 4s is more stable. Both Cu and Cr are at ground state. $1s^2$, $2s^2$, $2p^6$, $3s^1 3p^2$ should be $3s^2 3p^1$ (Aluminium ground state) so this is excited state.
iv. is at ground state
v. with $4s^1 4p^1$ should be $4s^2$ so this is in an excited state

6. Below are the electronic configurations of 4 ions.

i. $1s^2, 2s^2, 2p^6, 3s^2, 3p^6$
ii. $1s^2, 2s^2, 2p^6$
iii. $1s^2, 2s^2, 2p^6, 3s^2, 3p^6$
iv. $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^9$

Which option below best relates the ion to the electronic configuration.

a) i belongs to Ar^{2+}
b) ii. belongs to Al^{2+}
c) iii. belongs to Mg^+
d) iv. belongs to Cu^{2+}

$1s^2 2s^2 2p^6 3s^2 3p^6$ total number of electrons = 18. This is the same as argon (Ar), Ar^{2+} would have 16 electrons, not 18
ii. $1s^2 2s^2 2p^6$ total electrons = 10. This is not Al^{2+} 11 electrons, not 10.
iii. $1s^2 2s^2 2p^6 3s^2 3p^6$. Again 18 electrons, where as Mg^+ has 11 electrons, not 18
iv. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$. Total number of electrons = 27 Cu^{2+} has = 27 electrons. This is correct

The information below relates to questions 7 - 9
Consider the four molecular substances listed below.
CH_3NH_2, NH_3, CO_2, HCl

7. Which compound has the lowest boiling temperature

a) CH_3NH_2
b) CO_2
c) NH_3
d) HCl

Compare intermolecular forces
CH_3NH_2 → hydrogen bonding + dispersion
NH_3 → hydrogen bonding + dispersion
HCl → dipole–dipole + dispersion
CO_2 → London dispersion only (nonpolar)
Weakest forces = lowest boiling point as it takes less energy to overcome these forces. So CO_2 is the answer

8. Which are symmetrical molecules?

a) CH_3NH_2 and NH_3 only
b) CO_2 only
c) NH_3 and CO_2 only
d) HCl and CO_2 only

9. Liquid propane ($CH_3CH_2CH_3$) can dissolve fully in:
   a) $CH_3NH_2(l)$
   b) $CO_2(l)$
   c) $NH_3(l)$
   d) $HCl(l)$

Solutes dissolve in solvents that have similar intermolecular forces. Propane is a hydrocarbon (non-polar) and has dispersion forces only as the intermolecular force. CO_2 also is non-polar and hence dispersion forces on ly hence a likely match and the two substances can interact with each other via dispersion forces.

The following information shown in fig. 1 relates to questions 10 – 13

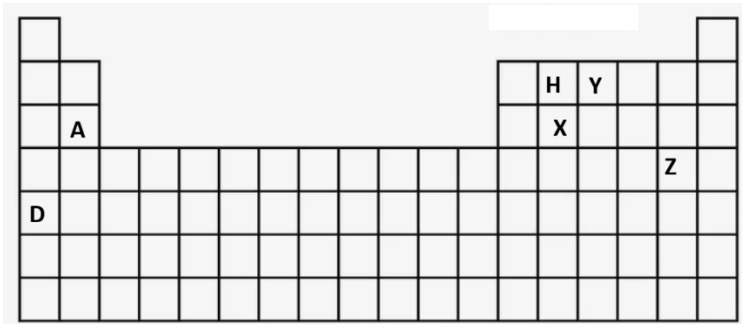


Figure 1 – Periodic table showing the position of 6 elements

10. A new substance is formed from the reaction between elements Y and Z. Which one of the following options is true?
    a) The substance has the formula YZ_4 and has weak dispersion forces as the only intermolecular force present.
    b) The substance has the formula ZY_3 and has weak dispersion forces as well as dipole-dipole interactions.
    c) The substance has the formula ZY_3 and forms a strong 3-dimenional network lattice of positive and negative ions.
    d) The substance has the formula YZ_4 with weak dipole-dipole interactions .

Y and Z are two non-metals that will react to form molecular compound (ZY_3) with polar covalent bonds. The intermolecular forces consist of dispersion forces and dipole-dipole interactions.

11. A new substance is formed from the reaction between elements A and Z. Which one of the following options is true?
    a) The substance will be brittle and conduct electricity in the solid state.
    b) The substance will be a gas at room temperature .

c) The substance will be malleable and conduct electricity in the solid state.

d) The substance will be brittle and conduct electricity in the aqueous state.

Metal A and non-metal Z will react to form an ionic compound (AZ_2). The properties of ionic substances, include, brittleness and the ability to conduct electricity in the liquid or aqueous states.

12. Which one of the following options is true about element H?

a) Element H has a crystal lattice composed of covalent bonds only.

b) Element H has a crystal lattice composed of positive and negative ions.

c) Element H is most likely a gas at room temperature.

d) Element H has a crystal lattice composed of positive ions and delocalized electrons.

This element, most likely C, has 4 valence electrons and is most likely a 3D or 2D covalent lattice in the solid state.

13. The following unknown element has three isotopes. The isotopic mass and the percentage abundance are given below.

Isotope	Isotopic mass (amu)	Percentage abundance
X	45	20
Z	47	65
Y	53	15

The average atomic mass is

a) 49.6 amu

b) 51.5 amu

c) 47.5 amu

a) 52.3 amu

Average atomic mass=((45×20)+(47×65)+(53×15))/100 = 47.5

14. Consider the crystal structure of compound Z as shown in fig. 2 on the right.
Which one of the following statements is true regarding the compound.

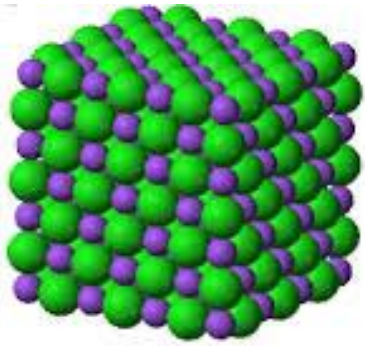


Figure 2 – shows the crystal structure of compound Z

a) It will conduct electricity, in the solid state only, as it is composed of ions.
b) It will have a low melting point as ions will move such that similar charged ions will repel each other.
c) It will be malleable in the solid state and able to be hammered into different shapes.
d) Compound Z exists as a liquid only at relatively high temperatures due to strong electrostatic forces of attraction that exist between particles in the lattice.

Compound Z is an ionic substance. A such it is brittle due to directional forces and conducts electricity only in the liquid and aqueous states. Ionic substances generally have relatively high melting points due to the strong electrostatic forces of attraction within the ionic lattice.

The information below is relevant to questions 15-16

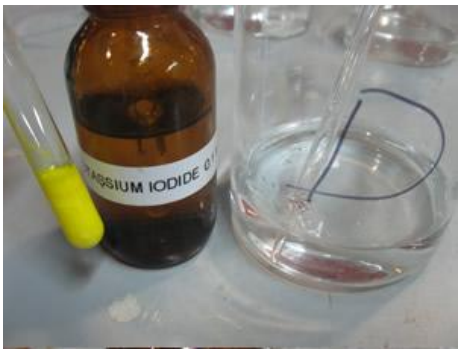


Figure 3 – A yellow precipitates is formed between potassium iodide and a clear solution.

15. Which of the following contaminants is most likely present in the clear solution?
a) Ammonium nitrate
b) Sodium phosphate
c) Potassium nitrate
d) Lead(II) nitrate

Lead nitrate is the only reactant that can produce a precipitate. All other options produce compounds that are soluble eg have ammonium, sodium, nitrate or potassium in the name which makes them soluble.

.

16. A student suggested that silver nitrate may be present in the clear solution. Which option represents the reaction taking place if silver nitrate was present?

a) $Ag(NO_3)(aq) + KI((s) \rightarrow AgI(aq) + KNO_3(aq)$
b) $AgNO_3(aq) + KI((s) \rightarrow AgI(aq) + KNO_3(aq)$
c) $AgNO_3(aq) + KI((aq) \rightarrow AgI(s) + KNO_3(aq)$
d) $AgNO_3(aq) + KI((s) \rightarrow AgI(s) + KNO_3(aq)$

Reactants must be aqueous and AgI needs to be a solid.
$AgNO_3(aq) + KI((aq) \rightarrow AgI(s) + KNO_3(aq)$

Data booklet should be used to see if a compound is soluble or insoluble. AgI is insoluble.

17. Magnesium nitrate solution is mixed with a solution of sodium phosphate. Which option below represents the net ionic equation for this reaction?

a) $3Mg^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Mg_3(PO_4)_2(s)$
b) $Mg^{2+}(aq) + PO_4^{2-}(aq) \rightarrow MgPO_4(s)$
c) $2Mg^{2+}(aq) + PO_4^{-}(aq) \rightarrow Mg_2PO_4\ (s)$
d) $3Mg^{2+}(aq) + 2PO_4^{3-}(s) \rightarrow Mg_3(PO_4)_2(s)$

Equation should only show the ions along with their state that take part in the reactions and their charge. It should be balanced for ions and charge.
Data booklet should be used to see if a compound is soluble or insoluble.

18. Consider the density toy shown on the right in fig. 4. Which two liquids can be used for this toy to work as it does?

a) C_6H_{14} and H_2O
b) C_9H_{20} and C_8H_{18}
c) NH_3 and H_2O
d) HCl and H_2O

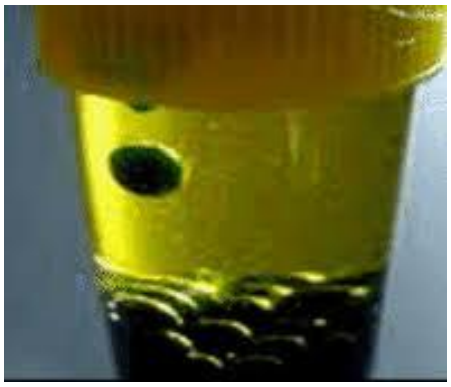


Figure 4 – A density toy

Substances with similar intermolecular forces will interact with each other and mix. Option B has both substances with dispersion forces only as the intermolecular force present. Option C both have H-bonding as the dominant force, whilst options d both are polar molecules with similar dipole-dipole interactions (HCl) and H-bonding(H_2O) that can interact with each other. Option a is the only one that will not mix as their intermolecular forces are totally different in strength. C_6H_{14} has dispersion forces only whilst H_2O has H-bonding as the dominant force.

19. Consider the table of reactive metals shown in fig. 5. Which one of the following options is a practical metal to use as a sacrificial anode to protect an iron nail from rusting when placed in water?

a) Zn
b) Fe
c) Tin
d) Na

A more reactive metal than Fe can be used. The word "practical " in the stem of the question negates the use of Na. As this metal is highly reactive with water and produces H_2 gas.

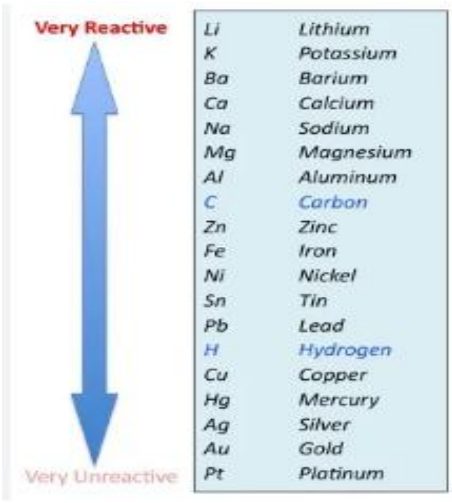


Figure 5 – Table of reactive metals.

20. Consider the chromatogram shown in fig. 6 of a mixture of dyes. The chromatogram was developed using water as a solvent. What does the chromatogram reveal about the molecules of each dye?

a) The molecules of the blue dye do not dissolve in water
b) The red dye has the most polar molecules
c) The red dye has the most non-polar molecules
d) The green dye has the most polar molecule

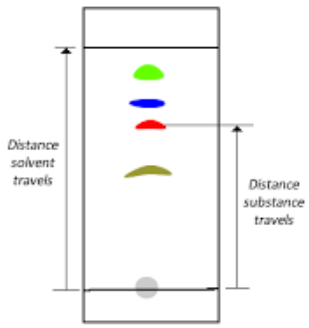


Figure 6 – A chromatogram of a mixture of dyes.

The dye that is most soluble in the solvent (H_2O) will move up the paper the greatest distance. Having similar intermolecular forces means it can interact with the solvent mobile phase (H_2O) and be carried along with the solvent up the paper. Dyes that do not have similar intermolecular forces with the mobile phase will spend less time in the solvent and more time adsorbing (sticking) to the stionary phase, which is the paper.

Section B

1. Consider the four molecules SO_3, NH_3, CH_4 and C_2H_6 .
   a. Place the molecules in order of increasing boiling temperature(BP) and give an explanation as to why SO_3 is placed at the top of the list with the highest BP.
   Low _____ , _____ , _____ , _____SO_3 _____High

1 -----mark for correct order (CH_4, C_2H_6,NH_3, SO_3)
1-----mark for correctly stating the different intermolecular forces at play.
1-----mark for correctly stating the difference in size of non-polar molecules which lead to greater strength dispersion forces to differentiate between CH_4 and C_2H_6.

   b. Complete the table below by circling the correct response *5 marks*

	SO_3	CH_4	NH_3	O_2
Intermolecular forces	Dispersion forces Dipole-dipole interactions Hydrogen bonding	Dispersion forces Dipole-dipole interactions Hydrogen bonding	Dispersion forces Dipole-dipole interactions Hydrogen bonding	Dispersion forces Dipole-dipole interactions Hydrogen bonding
Intramolecular bonding	Polar covalent Non-polar covalent Ionic	Polar covalent Non-polar covalent Ionic	Polar covalent Non-polar covalent Ionic	Polar covalent Non-polar covalent Ionic

c. Using the molecules HCl and Cl_2, explain how polar and non-polar covalent bonds form, and include diagrams of each molecule.

1-----mark for mentioning non-metal atoms with different electronegativities form polar covalent bonds unequally.
1-----mark for drawing each of the two molecules correctly
1-----mark with HCl having the correct permanent dipoles on each atom and Cl_2 not showing any permanent dipoles.

d. In the box below clearly draw a labelled diagram of the structure of a Cu metal lattice and use the diagram to explain three properties of metals, malleability, high melting temperatures and heat conductivity.

1-----mark for drawing a lattice composed of cations (Cu^{2+}), clearly shown, in a sea of delocalized electrons. Delocalised electrons clearly labelled.

1-----mark for correctly identifying <u>non-directional</u> force of attraction between cations and sea of delocalized electrons as a strong force that enables metals to be hammered into different shapes and have high melting temperatures.

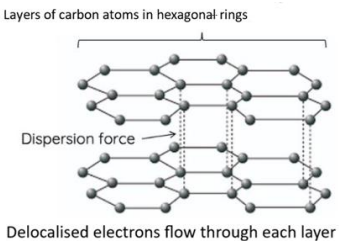
1-----mark for correctly stating the delocalized electrons as a vehicle for transferring heat across the metal.

e. Aluminium oxide melts at 2072 °C whilst NaCl melts at 801 °C. Explain the difference in melting temperatures between the two compounds.
1-----mark for correctly assigning charges to the ions of each compound.
1-----mark for correctly stating the higher charge leads to greater electrostatic force of attraction between the cations and anions.

f. CO_2 is a small molecule that turns from a solid to a gas (sublimes) at around -75 °C, whilst SiO_2 melts at 1713 °C. Explain why?

1-----mark for stating that CO_2 is molecular substance held together, in th solid state, by dispersion forces only.
1----- mark SiO_2 is a 3D covalent lattice which has strong covalent bonds holding the atoms in the lattice. Mark also awarded if diagram was used to explain rather than written response.
1-----mark - far more energy is required to break the covalent bonds in SiO_2, giving it a much higher melting point than the dipersion forces between CO_2 molecules.

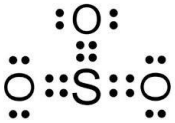
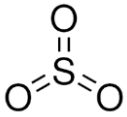
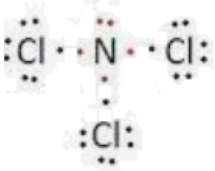
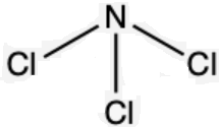
g. Graphite and diamond are made of carbon atoms covalently bonded to each other. Both substances occur naturally. Diamond is extremely strong, used to drill through hard rock whilst graphite is a lubricant for heavy machinery and unlike diamond conducts electricity in the solid state. Explain the difference in properties. Use a diagram in the box provided to assist your explanation.

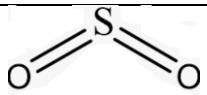
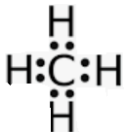
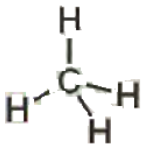


1-----mark for correct shape of diamond eg. Tetrahedral arrangement around each carbon and correctly identifying non-polar covalent bonds.
1-----mark correctly drawing a hexagonal layered structure for graphite clearly labelling dispersion forces between layers and delocalized electrons within layers.
1-----mark for correctly attributing properties at least one, to diamond based on its structure. For example, very high melting point (under high pressures), does not conduct, this is due to strong covalent bonds in 3D and no delocalized electrons present. No need to mention high pressure for MP to get the mark.
1-----mark for correctly attributing at least one property of graphite with an explanation. For example lubricant due to sliding layers due to dispersion forces and conducts electricity in the solid state due to delocalized electrons.

2. In the table below, correctly fill the remaining cells. *6 marks*

½----- mark for each correct answer

Formula	Lewis dot diagram	Structural formula	Shape	Symmetry
Cl_2		*Cl - Cl*	*Linear*	Symmetrical Asymmetrical
SO_3			*Trigonal planar*	Symmetrical Asymmetrical
NCl_3			*Triangular pyramid*	Symmetrical Asymmetrical
SO_2				Symmetrical

			*V-shape*	Asymmetrical
CH_4			*Tetrahedral*	Symmetrical Asymmetrical

3. Two solutions are mixed as per fig. 8. A red precipitate is formed.

Figure 8 – The precipitate formed when silver nitrate is mixed with sodium dichromate

a. Name the precipitate that is shown in fig.8.

_____*Silver dichromate*_____ *1 mark*

b. Give the chemical formula of the precipitate.

_____*$Ag_2Cr_2O_7$*_____ *1 mark*

c. Give the overall chemical equation for this reaction. States included

$Na_2Cr_2O_7\,(aq) + 2AgNO_3(aq) \rightarrow Ag_2Cr_2O_7(s) + 2NaNO_3(aq)$

1-----mark correct formulae
1-----mark correct states
1-----mark balanced for elements

d. Give the net ionic equation for the reaction taking place.

$Cr_2O_7^{2-}\,(aq) + 2Ag^+(aq) \rightarrow Ag_2Cr_2O_7(s)$

1-----mark for correct ions with states

1-----mark balanced for charge

e. In another experiment, two solutions, potassium phosphate and aluminium nitrate are mixed.

i. With reference to your 2026 data booklet suggest why a precipitate is likely to form.

1-----mark aluminium phosphate is insoluble

ii. Give the name and formula of the precipitate

Name _____ *aluminium phosphate* _____ *1 mark*

Formula _____ $Al_2(PO_4)_3$

1-----mark for correct ions

1-----mark for correct use of brackets

iii. Identify the spectator ions

Potassium (K^+) nitrate (NO_3^-)

1-----mark given for either name or formula with correct charge

4. Consider the results of a metal displacement experiment conducted in class, shown in

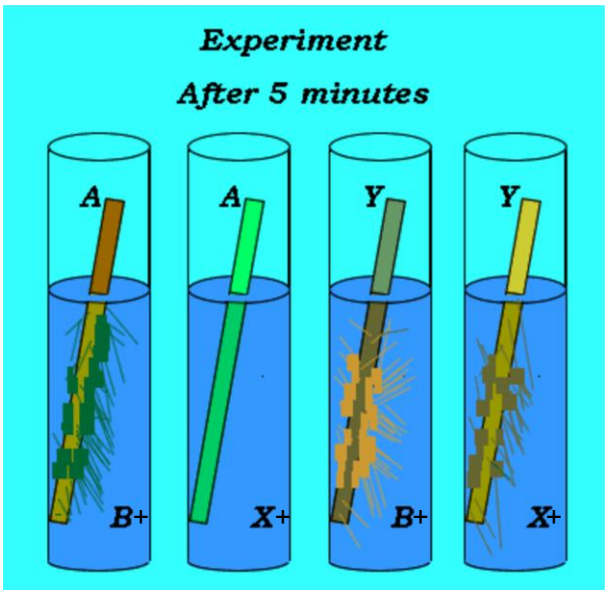


Figure 9 – metal displacement experiment

fig. 9. It involves metals A, X, B and Y.

a. Place the metals in order of increasing reactivity. *1 mark*

Low _____*B*_____, _____*A*_____, _____*X*_____, _____ *Y*_____, High

b. A bridge is made of metal X. The bolts holding the beams together are made of metal X. Overtime the bridge i8s in need of repair. Explain how the bolts will be impacted and give an explanation based on the experimental results shown in fig. 9.

1-----mark suggesting that both bridge and bolts are made from the same metal therefore no reactivity difference.
1-----mark for stating no change or both metal forming the bridge and bolts will rust at the samet rate.
1-----no electrons will be exchanged between the bolts and the metal forming the bridge.

5. Consider the two chromatograms shown below in fig. 10. Water was used as the mobile phase. Chromatogram A and B were made from two different brands of black texta.

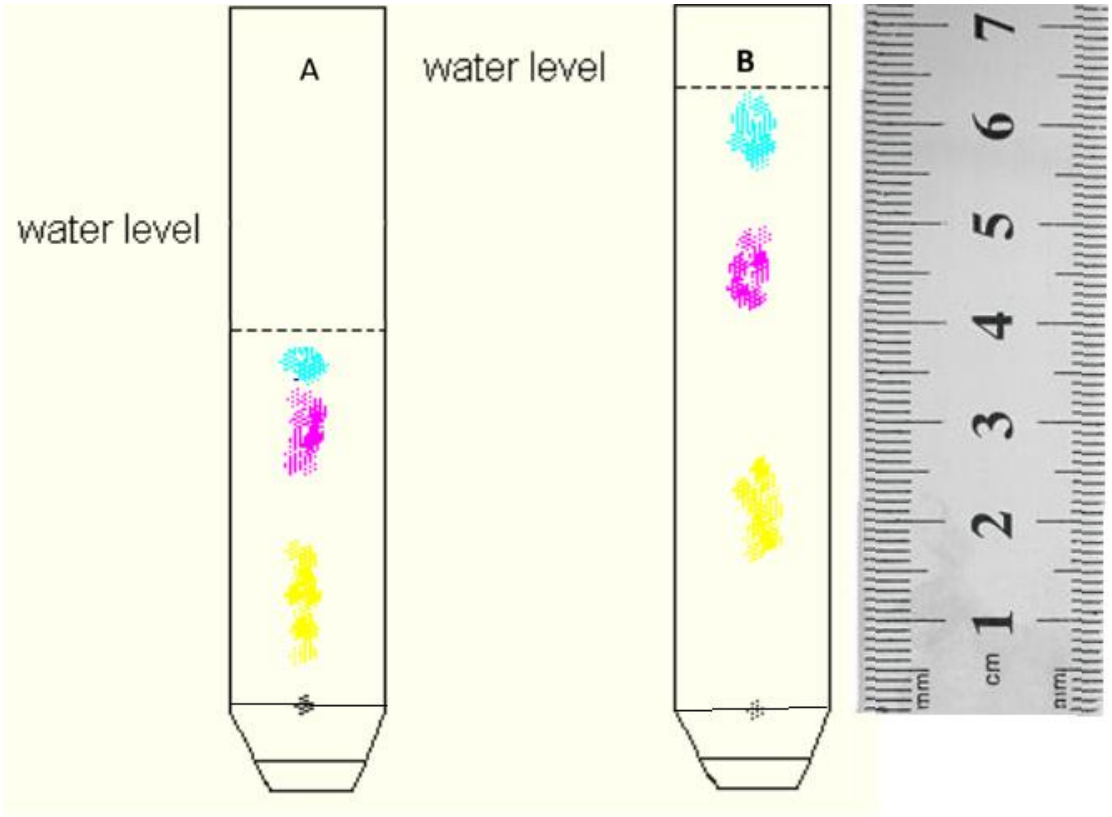


Figure 10 – chromatograms of two different brands of black texta, produced under identical conditions

a) Which colour, if any, appears to be used in both brands of texta. Justify your answer.

1-----mark for selecting a colour with an R_f

1-----mark for a calculation of R_f

1-----mark for equating the same colour with the same R_f value at each chromatogram

b)

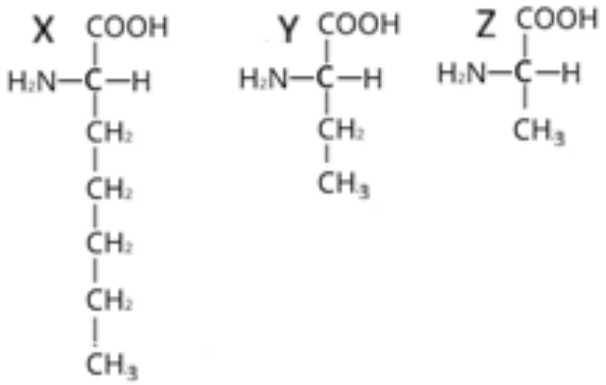


Figure 11 – three molecules that were in the ink that produced chromatogram A.

Associate each molecule in fig. 11 to a colour and justify your answer.

1-----mark for relating polarity with solubility in water (more soluble the greater the polarity of the molecule, longer the carbon chain the lower the solubility in water)

1-----mark for linking the length of the carbon chain with the solubility in water.

1-----mark for correct association of colour . blue = z red = y, yellow = X.

End of assessment.