ANSWERS TO GENERAL PAPER, 2008

1. **B:** **Polarization** is an exclusive property of **transverse waves**. Both longitudinal waves and transverse waves exhibit reflection, refraction, interference and diffraction, but polarization is exhibited by transverse waves only!

2. **B**

3. **A**. To evaluate their **relative specific heat capacities**, you just consider their degree of heat conductivity. The good heat conductors have a lower specific heat capacity (SHC), while the poor heat conductors have a higher SHC. This is because they require higher amounts of heat to attain temperature rise.
Hydrogen, Copper and Lead are all metals and so their SHC must be less than that of water.

4. **B:** The others may be replenished or improved upon, but not solar energy.

5. **D**

6. **C:** This illustrates the phenomenon of isotopy. **Isotopy** is observed when atoms of the same element have the same atomic number but different mass numbers; due to differences in the neutron number i.e. one isotope has more neutrons compared to the other.
Protons and **neutrons** are responsible for the **mass of the atom**, i.e. physical properties.
(the number of protons is the **atomic number** of the atom. It gives the **"chemical identity"** of an element).
Electrons are responsible for the **chemical properties**. This is because ordinary chemical reactions involve bond formation and bond breakage; electrons are used in bond formation, and separated in bond breakage.

7. Velocity of sound echo, $v = \frac{2x}{t} = f\lambda$

However, note that in the question "v" wasn't given, but parameters used to find velocity have been provided.

Therefore $v = f\lambda = 260 \times 1.2 = 312\text{m/s}$

To find the distance, x: $x = \frac{vt}{2}$ *From* $v = \frac{2x}{t}$

$$x = \frac{312 \times 2}{2} = 312\text{m}$$

A

8. A discharge tube experiment is done to study the discharge of electricity through gases. Under normal pressure, gases do not conduct electricity. However. at a **very high voltage** (p.d.) and **low pressure** gases conduct electricity and, at such the gas glows brightly

D

9. **D:** Such species that have the same number of electrons are termed **"iso-electronic species"**.
K^+ has 18 electrons, because the neutral atom K, which had 19 electrons, lost one electron to form a univalent cation.
Cl^- has 18 electrons because the neutral atom Cl, which had 17 electrons, gained one electron to form a univalent anion. Therefore both K^+ and Cl^- have 18 electrons just like argon, a noble gas with 18 electrons.
NB:
i. In the neutral state, the atomic number (number of protons) is the **same as** the number of electrons.
ii. Anions before, and cations after a noble gas are usually iso-electronic with that noble gas. e.g. O^{2-}, F^-, Ne, Na^+, Mg^{2+}, Al^{3+}, all have the same number of electrons (10 electrons just like neon). Cl^-, Ar, K^+, and Ca^{2+} all have 18 electrons.
iii. The ionic radius decreases as the effective nuclear charge (number of protons in the nucleus) increases, that is, as the iso-electronic species becomes more positive.

10. This question is based on John **Dalton's Law of partial pressures** which states that
"If there is a mixture of gases which do not react chemically together, then the total pressure exerted by the mixture is a sum total of the individual partial pressures of the gases that make up the mixture". i.e.

$P_{Total} = P_A + P_B + P_C + \ldots P_n$ .....(*i*)

From (i) above, it has been found that the partial pressure of a particular gas in a mixture is proportional to the number of moles (or molecules) of that gas. Thus, the higher the number of moles, the greater the partial pressure exerted by that gas component.
Mole fraction is the **fraction** of a component of mixture, calculated for using the number of moles for each. For instance, the mole fraction of gas A, X_A

$$X_A = \frac{n_A}{n_A + n_B + n_C} \text{.....(ii)} \qquad \text{(n = number of moles)}$$

The partial pressure (in terms of mole fraction) is defined as the **product** of the mole fraction and the total pressure e.g. for gas A in the mixture.

$P_A = X_A \cdot P_{Total}$ .....(*iii*)

For the question in focus:

$P_{He} = X_{He} \cdot P_{Total}$ .....(*iv*)

(P_{He} = Partial pressure of Helium, X_{He} = mole fraction of Helium, P_{Total} = Total pressure of the mixture of gases).

$$X_{He} = \frac{n_{He}}{n_{Ar} + n_{Ne} + n_{He}}$$

$$X_{He} = \frac{0.30}{0.20 + 0.20 + 0.30} = 0.43$$

From equation (iv)

$P_{He} = 0.43 \times 2.1 = 0.9$ atm

C

NB:

(i) Mole fraction has no unit

(ii) The mole fraction of any component is always less than 1 (because it is a fraction)

(iii) The sum of the mole tractions of all the components always equal 1.

11. **NB:** The sum of pH and pOH for any acid or base always equal 14. i.e.

$$pH + pOH = 14$$

$$\therefore \quad pH = 14 - pOH \quad \text{.....(i)}$$

Since we are to find the hydrogen ion concentration, it is more convenient to work in terms of pH, since there is a relationship between pH and $[H^+]$, according to Sorensen's equation given below (ii).

$$pH = -\log [H^+] \quad \text{.....(ii)}$$

From equation (i)

$pH = 14 - 12.23$

$= 1.77$

Hydrogen ion concentration $[H^+]$, usually takes the form of:

$$\mathbf{[H^+] = a \times 10^{-n}} \quad \text{..... (iii)}$$

"a" is any number from 1.00 to just less than 10.00. (i.e. 9.9). **"n"** is a whole number from 1 to 14.

When "a" is not exactly 1.00, then pH is between n - 1 and n. (If "a" is exactly 1.00, then pH = n).

In this case, pH = 1.77, which is between 1 (n -1) and 2 (n). Therefore n = 2.

Equation (iii) may now be modified as:

$$[H^+] = a \times 10^{-2}$$

To find the "a" part, remember that another expression for pH, when $[H^+] = a \times 10^{-n}$ is: $\mathbf{pH = n - \log a}$ .....(iv)

(Equation (iv) is as important as equation (iii))

Substituting:

$1.77 = 2 - \log a$

$1.77 - 2 = -\log a$

$-0.23 = -\log a$

$\log a = 0.23$

$a = \log^{-1} 0.23$

i.e. take the antilog of 0.23. This can be found easily using the four-figure tables.

$a = 1.698$

Therefore hydrogen ion concentration $[H^+]$ is

$$\mathbf{[H^+] = 1.698 \times 10^{-2}}$$

B

Thus we have solved a question on calculation of pH/hydrogen ion concentration without a calculator! (QED).

12. **A:** Plutonium is not naturally occurring; it is produced by artificial means. The others are members of the Lanthanide and Actinide series

13. **D:** In double decomposition, two soluble compounds react to produce one soluble compound and an insoluble salt which **precipitates** out of solution.

Examples of such precipitates, which are insoluble in water are the sulphates of Barium, Lead and Calcium ("BaLeCa") and the chlorides of Lead, Copper, Mercury and Silicon ("LeCuMeSi")

An example to illustrate the precipitations of $BaSO_4$, an insoluble salt, is represented ionically as

$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ is:

$Na_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2NaCl$

Or

$2Na^+SO_4^{2-} + Ba^{2+}2Cl^- \rightarrow Ba^{2+}SO_4^{2-} + 2Na^+2Cl^-$

If the Na^+ and Cl^- ions are cancelled out, then the ionic equation given previously is left behind!

14. **B:** White phosphorus has a low ignition temperature (35°C) and thus catches fire spontaneously in air. Therefore it needs to be stored under water.
NB. Phosphorus has three (3) allotropes namely **white phosphorus, red phosphorus** and black **phosphorus** (allotropes are the different physical forms of the same element.)
Please see a chemistry textbook for the details of properties of each allotrope.

15. $Al_2(SO_4)_3 + 8NaOH \rightarrow 2NaAl(OH)_4 + 3Na_2SO_4$
$NaAl(OH)_4$ is formed

C

16. **C:** Copper + Tin (Cu and Sn) = Bronze
Soft solder always contains Lead and Tin (Pb and Sn). It may additionally contain Antimony (Sb).
Brass is a mixture of Copper and Zinc (Cu and Zn).

17. **A:** Both kerosene and petrol (gasoline) are mixtures of hydrocarbons compounds. The hydrocarbons in kerosene (12 - 18 carbon atoms) have higher molecular weights compared to those in petrol (4 - 12 carbon atoms). Therefore petrol is **more volatile** than kerosene.
The table below gives a summary of the fractions of petroleum.

Fraction	Number of carbon atoms	Temperature of distillation	Physical properties	Uses
Petroleum gases	1 - 4	< 40°C	Gases	Domestic and industrial fuels, for making CCl_4, ethyne.
Petroleum ethers and ligroin(light naphtha)	5 - 7	Petroleum ether: 2 – 60°C Ligroin: 60 – 100°C	Very volatile liquids	Organic solvents, fuels.
Petrol (gasoline)	4 - 12	40 – 200°C	Volatile liquid	Fuel for vehicles, aeroplanes, and as solvent for paint and grease.
Kerosene	12 - 18	200 – 250°C	Fairly volatile liquid	Fuel for lighting, heating and jet engines. Solvents for paints and grease
Gas oil and diesel oil	12 - 25	250 – 350°C	"thicker" than kerosene.	Fuel for heating and diesel engines. Raw material for cracking
Lubricating oils	> 20	350 – 500°C	Heavy oils	Lubricating moving parts of machines. Making candles, creams and hair-care products.
Bitumen	> 35	Above 500°C	Black solid residues	Tarring of roads, coating of pipes and waterproofing of roofs.

18. H_2SO_4 dehydrates ethanol to yield **ethoxyethane**. (diethyl ether). The suphuric acid acts as a **catalyst** as it is regenerated at the end of the reaction

(i) $C_2H_5OH + H_2SO_4 \rightarrow C_2H_5HSO_4 + H_2O$

(ii) $C_2H_5HSO_4 + C_2H_5OH \rightarrow C_2H_5OC_2H_5 + H_2SO_4$

The condition for this reaction is that ethanol is in excess and the temperature of the system is low.

A

19. Palm oil contains **palmitic acid**, which has 16 carbon atoms. Fatty acids may be **saturated** or **unsaturated**. Saturated fatty acids generally have a hydrocarbon chain, ending in a carboxylic acid functional group, and there do not have double or triple bonds. Unsaturated fatty acids have a more complex structure, and contain double bonds.

A

Below is a table of summary of **fatty acids and their properties.**

Saturated Fatty Acids

No of Carbon atoms	Formula	Trivial names	Systematic (IUPAC) names
2	CH_3COOH	Acetic acid	Ethanoic acid
4	C_3H_7COOH	Butyric acid	Butanoic acid
5	C_4H_9COOH	Valeric acid	Pentanoic acid
6	$C_5H_{11}COOH$	Caproic acid	Hexanoic acid
7	$C_6H_{13}COOH$	Enanthic acid	Heptanoic acid
8	$C_7H_{15}COOH$	Caprylic acid	Octanoic acid
9	$C_8H_{17}COOH$	Petargonic acid	Nonanoic acid
10	$C_9H_{19}COOH$	Capric acid	Decanoic acid
12	$C_{11}H_{25}COOH$	Lauric acid	Dodecanoic acid
14	$C_{13}H_{27}COOH$	Myristic acid	Tetradecanoic acid
16	$C_{15}H_{31}COOH$	Palmitic acid	Hexadecanoic acid
17	$C_{16}H_{33}COOH$	Margaric acid	Heptadecanoic acid
18	$C_{17}H_{35}COOH$	Stearic acid	Octadecanoic acid
20	$C_{19}H_{39}COOH$	Arachidic acid	Eicosanoic acid
22	$C_{21}H_{43}COOH$	Behenic acid	Docosanoic acid
24	$C_{23}H_{47}COOH$	Lignoceric acid	Tetracosanoic acid

Unsaturated Fatty Acids

No of Carbon atoms	Trivial names	Systematic (IUPAC) names
14	Myristoleic acid	9-Tetradecenoic acid
16	Palmitoleic acid	9-Hexadecenoic acid
18	Oleic acid	9-Octadecenoic acid
18	Vaccenic acid	11-Octadecenoic acid
18	Linoleic acid	9,12-Octadecadienoic acid
18	Linolenic acid	9,12,15-Octadecatrienoic acid
20	Gadoleic acid	9-Eicosenoic acid
20	Arachidonic acid	5,8,11,14-Eicosatetraenoic acid

Note that the saturated fatty acid nomenclature end with – **oic**, while that of the unsaturated end with **enoic**. Note also that the numbers before the nomenclature of the unsaturated fatty acids represents carbon atom positions in which there are double bonds i.e. points of unsaturation.

20. The hydrolysis of lipids produce fatty acids and glycerol. Fatty acids, as the name implies have acidic properties; glycerol is an alcohol (propan-1,2,3-triol).

C

21. The process of manufacturing soap is "Saponification" and it is a reaction between lipids and Sodium hydroxide or Potassium hydroxide.

$$\text{Lipid} + \text{NaOH} \xrightarrow{heat} \text{soap} + \text{alcohol}$$

The products are **'soap'** and **'polyhydric alcohol'**

B

22. Plastics are classified as
(i) Thermoplastics (thermoplasts) and
(ii) Thermosets
Thermoplastics can be softened repeatedly by heat and can therefore be remoulded into different shapes.
Thermosets on the other hand cannot be melted or softened by heart once they have been formed or set. i.e., thermosets cannot be remoulded after formation.
Thermoplasts include; Nylon, terylene, perspex, polystyrene, polythene, polypropene etc.
Thermosets include urea-methanol compounds, Bakelite and **methanol containing products**

A

23. **C**

24. Distance covered in the 10^{th} second:
= Distance covered after 10 seconds – Distance covered after 9 seconds
i.e. $S_{nth} = S_n - S_{n-1}$.
$u = 0$, $a = 8m/s^2$, $t = 10sec$,
Using: $s = ut + \frac{1}{2}at^2$
$s_{10} = 0 \times 10 + \frac{1}{2} \times 8 \times 10^2$
$= 400m.$
$s_9 = 0 \times 9 + \frac{1}{2} \times 8 \times 9^2$
$= 324m.$
$s_{10th} = S_{10} - S_9 = 400 - 324 = 76\ m$

A

25. **Tetanus** (lock-jaw) is caused by the bacteria ***clostridium tetani***. It is spread by contact of injured skin with contaminated soil, rusty nails, dust and faeces.
Measles is caused by the Rubiola virus, a paramyxovirus. It is spread by close contact and by air (air-borne).
Typhoid fever is caused by the bacteria, ***Salmonella typhi***. It is spread through food and water contaminated with human faeces.
Ringworm (tineasis) is caused by fungi of the **dermatophyte** group.
Antibiotics are specific and effective against bacteria, fungi and some parasites. They are ineffective against viruses e.g. the measles virus.
Recall that viruses are <u>obligate intracellular parasites</u> i.e. they cannot live, survive or reproduce outside a living cell (host cell).

B

26. Pests may be controlled by:
(i) **Physical methods** e.g. mechanical methods like crushing, burning of their breeding places etc.
(ii) **Chemical methods** e.g. use of pesticides, spraying stagnant water surface with chemicals etc.
(iii) **Biological methods** e.g. using the natural enemies of the pests to reduce their numbers. For instance, the presence of a cat in the house reduces the numbers of rats!

Increasing the population of the natural enemies of the pests reduces the population of the pests.

C

27. **Autotrophs** are able to manufacture their own food from simple compounds. For instance, photosynthetic plants manufacture glucose from carbon (IV) oxide and water in the presence of sunlight. The glucose thus produced is stored as starch. Autotrophs are thus **producers** and they are found at the beginning of the food chain.

C

Consumers (heterotophs) are unable to manufacture their own food and thus take in ready-made food e.g. herbivores, carnivores, omnivores etc.
Carnivores feed on animals **Decomposers** thrive on dead or decaying organic matter; they include fungi and certain bacteria. Decomposers are otherwise called **saprophytes**.

28. The human skeleton may be subdivided into two namely:
- Axial skeleton
- Appendicular skeleton

The **axial skeleton** (i.e. skeleton at the axis or centre) is made up of the skull, vertebral column the ribs and the sternum. The vertebral column comprises the cervical, thoracic and lumbar vertebrae as well as the sacrum and the coccyx.
The **appendicular skeleton** (i.e. skeleton that makes up the appendages (the appendages are upper and lower limbs) comprises the:

a. ***Upper limb bones:*** These are the clavicles, scapula, humerus, radius, ulna, the carpal bones, the metacarpals and the phalanges.
b. ***Lower limb bones:*** These are the pelvis, femur, tibia, fibular, the tarsal bones, the metatarsals and the phalanges.

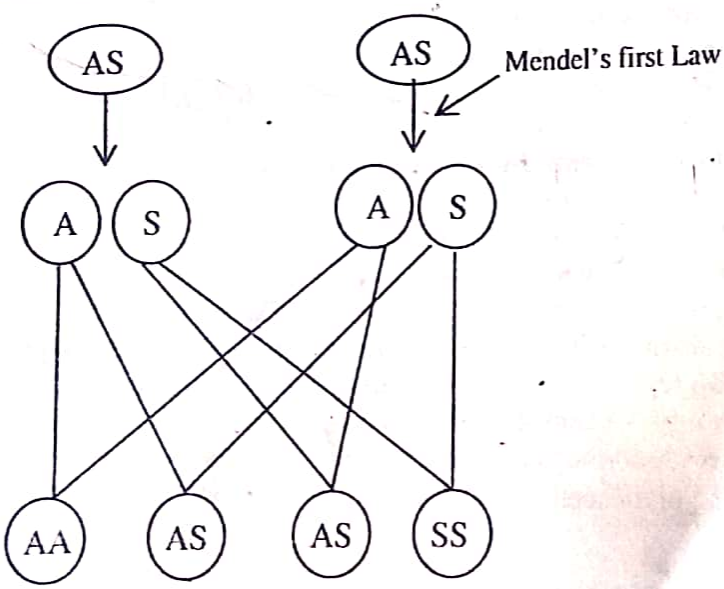
The sacrum is part of the vertebral column

B

29. For the sickle cell trait:
Hb^AHb^A = AA genotype
Hb^AHb^S = AS genotype
Hb^SHb^S = SS genotype
(NB: each haemoglobin gene that make up the genotypic pair is donated by a parent, either HbA or HbS. The particular combination is what determines the genotype of the offspring).
Persons with the **AA genotype** are **healthy, non-carriers**. They have no trait of the sickle cell disorder and therefore cannot transmit it to their offspring.

Individuals with the **AS genotype** are **healthy carriers**, i.e. they have the trait for the sickle cell disorder, but do not manifest clinical signs and symptoms. They can however transmit the disease to their offspring. Persons with the **SS genotype** are **sufferers**, i.e. they present with the numerous clinical signs and symptoms of the disease. Sickle cell disease patients often die young, if they are not treated.

In marriage cancelling, a couples that are both of the AS genotype are advised against getting married because there is a 25% or ¼ probability of producing a child with the SS genotype.



D

30. **A:** The prokaryotes are the bacteria. They fall into the classification **"Kingdom Monera"**. The algae (thallophytes) are simple green plants that are all aquatic. They may be thread-like (filamentous) or flat (thallus). They do not have roots, stems or leaves.

Spirogyra is a simple filamentous green alga. The **kelp**, a brown alga, has the thallus shape.
Tracheophytes are vascular plants (i.e. they have well developed conducting system for transporting water and food. They include the ferns and the seed plants (Gymnosperms and Angiosperms).

31. **A**
The hierarchy of living organisms is as follows:

Kingdom
Phylum (Division)
Subphylum*
Class
Order
Family
Genus
Species.

There are 7 or 8 levels of hierarchical classification. The Kingdom is the largest (there are five kingdoms – Monera, Protista, Fungi, Planate and Animalia), while the species refers to the specific name.
Man belongs to Kingdom - Animalia, Phylum - Chordata (animals with a notochord at one point or the other in their development), Subphylum - Vertebrata (animals with a backbone or vertebral column: examples of vertebrates are the Pisces (fishes), Amphibians, Retiles, Aves (birds), Mammals (e.g. man, goat, dog), Class - Animalia, Order - Primate, Family - Hominidae, Genus – Homo, and Species - Sapiens.

32. **Deficiency of sulphur** in plants causes **yellowing of the leaves** and **slender stems**. (Other minerals whose deficiency can cause yellowing of the leaves are **Nitrogen, Iron** and **Magnesium**).

C

NB: Read-up the deficiency symptoms of the other elements or minerals required by plants.

33. **C:** Many of the blood-clothing factors require **Vitamin K** for their synthesis. Deficiency of vitamin K causes **excessive bleeding**.
Deficiency of **Vitamin A** (also known as retinol or retinoic acid) causes scaly skin, night blindness and xerophthalmia (i.e. dryness of the eye, which may lead to blindness).
Deficiency of **Vitamin D** causes Rickets in children and softening of bones in adults (osteomalacia). Vitamin D (cholecalciferol) is required for strong bones and teeth formation, because it increases calcium and phosphorus absorption from the intestines. Calcium and phosphorus are important components of bone and teeth.
Vitamin E (tocopherol) protects the body's cell membranes against oxidation by reac ive oxygen species. That is it is an anti-oxidants vitamin (other anti-oxidant vitamins are Vitamins A and C).
Deficiency of **Vitamin B_1** (Thiamine) causes Beriberi, which is characterized by muscle wasting and paralysis.
Deficiency of **Vitamin B_2** (riboflavin) causes cracking of skin around the corners of the mouth, nose and eyes. (i.e. angular cheliosis or angular stomatitis)
Deficiency of **Vitamin B_3** (niacin or nicotinic acid) causes Pellagra.
Deficiency of **Vitamin B_5** (Pantothenic acid) causes disorders of the nervous system and the gastrointestinal tract (gut).
Lack of **Vitamin B_6** (pyridoxine) causes anaemia and diarrhoea.
Deficiency of **Vitamin B_{12}** (cyanocobalamin) causes pernicious anaemia
Lack of **folic acid** causes megaloblatic anaemia. B_{12} deficiency can cause this condition too.
Deficiency of **Vitamin C** (Ascorbic acid) causes scurvy. This disease is characterized by swelling of th gums and joints, loosening of the teeth and bleeding from the gums, skin and membranes.

34. **B:** A **nucleotide** has **three components**, namely:
- A **nitrogenous base** (purines or pyrimidines)
- A **pentose sugar** (usually ribose or deoxyribose sugar)
- **Phoshate** (backbone)

Six-carbon sugars such as glucose, fructose and galactose are not used in the formation of nucleotides!
NB: The term **nucleoside** refers to a combination of a nitrogenous base and a pentose sugar, without the phosphate group.

35. **Incomplete dominance** is one of the modifications to Mendelian genetics. Here, the effect of an allele is modified by the presence of the other to produce a third phenotype (recall that genes are transmitted in allelic pairs).
Examples of this are seen in the alleles of the four-O'clock plant, as well as the baldness gene.

A

(Other modifications to Mendelian genetics include: **Co-dominance, linkage** and **sex-linkage, multiple alleles, polygenic inheritance, mutation** and **non-disjunction**)

36. In Charles Darwin's Theory of Evolution, he proposed that:

(i) Most organism produce offspring in very large numbers, much more than can survive or live long enough to reproduce
(ii) The size of a population remains fairly constant because sources of food and shelter are limited
(iii) Individuals within a species show variation
(iv) Some variations are favourable for survival and individuals with these favourable variations survive.
In conclusion, Darwin propounded that in a population, individuals that are well adapted (i.e. have good competitive advantage by means of their variation) survive while those that are not well adapted die off. Such variations are passed down to the offspring. Darwin's theory is sometimes dubbed ***"Survival of the Fittest"***.
Mutation is not a component of Darwin's theory of evolution.

C

37. **B:** Mutants are species with altered genes. Radiations generally have the ability to cause mutation

38. **Homodont dentition** refers to a set of teeth in which the individual tooth have identical shape and sizes. Such dentition is seen in fishes (Pisces), lizards (Reptiles) and the toad (Amphibians).
In heterodont dentition, teeth are of different sizes and shapes (e.g. incisors, canine, premolars, molars). Such dentition is seen in mammals.
Lizard is a reptile (Homodont dentition) the rest are mammals (heterodont dentition).

NB:

(i) Herbivores such as the rabbit and sheep have no canines. In the place of the canine, a wide space lacking teeth is found and this 'space' is named diastema.
(ii) The dog has special teeth for crushing food, termed "**Carnassial teeth**". The Carnassial teeth is the **last upper premolar** and the **first lower molar** on both sides of the mouth.

39. A well cultivated land undergoes continuous interference by the activities of man and thus, is not kept for the development of a proper ecosystem, naturally. A pond, Savanna grassland and an abandoned farmland are not influenced by the activities of man and thus natural succession can take place in them.

C

40. All are correct!

E

In chemistry, the **'mole'** is the unit of measurement employed. A mole is the measure of a substance that contains the Avogadro number of particles (atoms, molecules or ions). That is, one mole of any substance contains 6.02×10^{23} particles of the substance.
The **weight of one mole** of a substance is the **molar mass** (expressed either as "g/mol" or simply "g").
The reason why the molar masses of the elements vary is because of the difference in the sizes of the individual atoms e.g. calcium atom is larger than the sodium atom.