Moles Test

No.1

To Pass the Moles Test you will need to achieve a score of greater than 70%. Each question is equally weighted (5%).

Relative Atomic Masses:
Hydrogen (H) = 1, Carbon (C) = 12, Nitrogen (N) = 14, Oxygen (O) = 16, Sodium (Na) = 23, Sulfur (S) = 32, Chlorine (Cl) = 35.5, Potassium (39), Calcium (Ca) = 40, Copper (Cu) = 63.5, Barium (Ba) = 137, Mercury(Hg) 200.5, Lead (Pb) = 207

Molar Volume: 22.4 dm^3 or 22,4000 cm^3 at STP (273.15 K and 1 atm)

Avodagdro's Number: 6.02×10^{23}

1. Rubidium is a soft, silvery-white metal that has two common isotopes, ^{85}Rb and ^{87}Rb. If the abundance of ^{85}Rb is 72.2% and the abundance of ^{87}Rb is 27.8%, what is the average atomic mass of rubidium?

2. An unknown compound was found to have a percent composition as follows: 47.0 % potassium, 14.5 % carbon, and 38.5 % oxygen. What is its empirical formula? If the true molar mass of the compound is 166.22 g mol^{-1}, what is its molecular formula?

3. Lead (IV) oxide reacts with concentrated hydrochloric acid as follows:

$$PbO_{2(s)} + 4HCl_{(aq)} \rightarrow PbCl_{2(s)} + Cl_{2(g)} + 2H_2O_{(l)}$$

What mass of lead chloride would be obtained from 37.2g of PbO_2, and what mass of chlorine gas would be produced?

4. In 1774 Joseph Priestly conducted one of his most famous experiments which lead to a method for the preparation of oxygen. The experiment involved heating a sample of mercury II oxide with a large lens.
The equation for this reaction is shown below:

$$2HgO(s) \rightarrow 2Hg(l) + O_{2(g)}$$

What volume of $O_2(g)$ would be obtained if 1.08g of mercury (II) oxide were completely decomposed? (Given that 1 mole of a gas occupies 24 dm^3 under the experimental conditions)

5. When copper (II) nitrate is heated, it decomposes according to the following equation:

$$2Cu(NO_3)_{2(s)} \rightarrow 2CuO(s) + 4NO_{2(g)} + O_{2(g)}$$

a) When 20.0g of copper (II) nitrate is heated, what mass of copper (II) oxide would be produced?

b) What mass of NO_2 would be produced?

6. A solution containing 0.732 mol of ammonia was made up to 250 cm^3 in a volumetric flask by adding water. Calculate the concentration of ammonia in this final solution and state the appropriate units.

7. Sodium hydride reacts with water according to the following equation.

$$NaH_{(s)} + H_2O_{(l)} \rightarrow NaOH_{(aq)} + H_{2\,(g)}$$

A 1.00 g sample of sodium hydride was added to water and the resulting solution was diluted to a volume of exactly 250 cm^3.

a) Calculate the concentration in $moldm^{-3}$, of sodium hydroxide solution formed.

b) Calculate the volume of hydrogen gas evolved, measured at STP.

c) Calculate the volume of 0.112 M hydrochloric acid which would react exactly with a 25.0 cm^3 sample of sodium hydroxide solution

8. Sodium carbonate forms a number of hydrates of general formula $Na_2CO_3.xH_2O$. A 3.01 g sample of one of these hydrates was dissolved in water and the solution made up to 250 cm^3. In a titration, a 25.0 cm^3 portion of this solution required 24.3 cm^3 of 0.200 M hydrochloric acid for complete reaction.

The equation for this reaction is shown below.

$$Na_2CO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

a) Calculate the number of moles of HCl in 24.3 cm^3 of 0.200 M hydrochloric acid.

b) Deduce the number of moles of Na_2CO_3 in 25.0 cm^3 of the Na_2CO_3 solution.

c) Hence deduce the number of moles of Na_2CO_3 in the original 250 cm^3 of solution.

d) Calculate the M_r of the hydrated sodium carbonate

9. A student knew adding calcium to water could make that calcium hydroxide. The student added 0.00131 mol of calcium to a beaker containing about 100 cm^3 of water. A reaction

took place as shown by the equation below. All the calcium hydroxide formed was soluble.

$$Ca_{(s)} + 2H_2O_{(l)} \rightarrow Ca(OH)_{2(aq)} + H_{2(g)}$$

a) Calculate the mass of calcium that the student added.

b) Calculate the volume of hydrogen gas, in dm^3, produced in this reaction at standard temperature and pressure, STP.

c) The student transferred the contents of the beaker to a 250cm^3 volumetric flask and water was added to make the solution up to 250 cm^3. Calculate the concentration, in M, of hydroxide ions in the 250 cm^3 solution.

10. A 1.0 kg sample of methane was burned in air. It reacted as follows:

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_2\,(g) + 2H_2O(g)$$

Calculate the volume of oxygen gas, measured at STP, which would be required for the complete combustion of 1.0 kg of methane.

11. When 5.175 g of lead are heated at 300°C the lead reacts with the oxygen in the air to produce 5.708 g of an oxide of lead. This is the only product. What is the equation for this reaction?

12. 4.90g of pure sulfuric acid was dissolved in water, the resulting total volume was 200 cm^3. 20.7 cm^3 of this solution was found on titration, to completely neutralise 10.0 cm^3 of a sodium hydroxide solution. [atomic masses: S = 32, O = 16, H = 1]

Calculate the concentration of the sodium hydroxide (M)

Moles Test

No.2

To Pass the Mole Test you will need to achieve a score of greater than 70%. Each question is equally weighted (5%).

Relative Atomic Masses:
Hydrogen (H) = 1, Carbon (C) = 12, Nitrogen (N) = 14, Oxygen (O) = 16, Sodium (Na) = 23, Magnesium (Mg = 24, Phosphorus(P) = 31,Silicon (Si) = 28, Sulfur (S) = 32, Chlorine (Cl) = 35.5, Lead (Pb) = 207

Molar Volume: 22,4000 cm^3 at STP (273.15 K and 1 atm)

Avodagdro's Number: 6.02 x 10^{23}

1. Titanium has five common isotopes: ^{46}Ti (8.0%), ^{47}Ti (7.8%), ^{48}Ti (73.4%), ^{49}Ti (5.5%), ^{50}Ti (5.3%). What is the average atomic mass of titanium?

2. A compound of Na, S and O contains 17.04% Na, 47.41% S. The M_r of the compound is 270. Calculate the empirical formula, and then the molecular formula.

3. In the sixteenth century, a large deposit of graphite was discovered in the Lake District. People at the time thought that the graphite was a form of lead. Nowadays, graphite is used in pencils but it is still referred to as 'pencil lead'. A student decided to investigate the number of carbon atoms in a 'pencil lead'. He found that the mass of the 'pencil lead' was 0.321 g.

a) Calculate the amount, in moles, of carbon atoms in the student's pencil lead. Assume that the 'pencil lead' is pure graphite.

b) Using the Avogadro constant, calculate the number of carbon atoms in the student's 'pencil lead'.

4. Calculate the concentration, in M, of the solution formed when 19.6 g of hydrogen chloride, HCl, are dissolved in water and the volume made up to 250 cm^3.

5. Calculate the mass of H_2O required to react completely with 5.0 g of $SiCl_4$:

$$SiCl_{4(l)} + 2H_2O_{(l)} \rightarrow SiO_{2(s)} + 4HCl_{(aq)}$$

6. The equation for the reaction between magnesium carbonate and hydrochloric acid is

given below.

$$MgCO_{3(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

When 75.0 cm^3 of 0.500 M hydrochloric acid were added to 1.25 g of impure $MgCO_3$ some acid was left unreacted. This unreacted acid required 21.6 cm^3 of a 0.500 M solution of sodium hydroxide for complete reaction.

a) Calculate the number of moles of HCl in 75.0 cm^3 of 0.500 M hydrochloric acid.

b) Calculate the number of moles of NaOH used to neutralise the unreacted HCl.

c) Show that the number of moles of HCl which reacted with the $MgCO_3$ in the sample was 0.0267.

Number of moles reacted with $MgCO_3$ = 0.0375 – 0.0108 = **0.0267**

d) Calculate the number of moles and the mass of $MgCO_3$ in the sample, and hence deduce the percentage by mass of in the sample.

7. Nitroglycerine, $C_3H_5N_3O_9$, is an explosive which, on detonation, decomposes rapidly to form a large number of gaseous molecules. The equation for this decomposition is given below.

$$4C_3H_5N_3O_{9\,(l)} \rightarrow 12CO_{2(g)} + 10H_2O_{(g)} + 6N_{2(g)} + O_{2(g)}$$

A sample of nitroglycerine was detonated and produced 0.350 g of oxygen gas

a) Calculate the number of moles of oxygen gas produced in this reaction, and hence deduce the total number of moles of gas formed.

b) Calculate the number of moles, and the mass, of nitroglycerine detonated.

8. What mass of lead(II) sulfate would be produced by the action of excess dilute sulphuric acid on 10 g of lead nitrate dissolved in water?

$$Pb(NO_3)_2(aq) + H_2SO_{4(aq)} \rightarrow PbSO_{4(s)} + 2HNO_{3(aq)}$$

9. Ammonium sulfate reacts with aqueous sodium hydroxide as shown by the equation below.

$$(NH_4)_2SO_{4(s)} + 2NaOH_{(aq)} \rightarrow 2NH_{3(aq)} + Na_2SO_{4(aq)} + 2H_2O_{(l)}$$

A sample of ammonium sulfate was heated with 100 cm^3 of 0.500 M aqueous sodium hydroxide. To ensure that all the ammonium sulfate reacted, an excess of sodium hydroxide was used. Heating was continued until all of the ammonia had been driven off as a gas. The unreacted sodium hydroxide remaining in the solution required 27.3 cm^3 of 0.600 M hydrochloric acid for neutralisation.

a) Calculate the original number of moles of NaOH in 100 cm^3 of 0.500 M aqueous sodium

hydroxide.

b) Calculate the number of moles of HCl in 27.3 cm^3 of 0.600 M hydrochloric acid.

c) Deduce the number of moles of the unreacted NaOH neutralised by the hydrochloric acid.

d) Calculate the number of moles of NaOH which reacted with the ammonium sulfate

e) Calculate the number of moles and the mass of ammonium sulfate in the sample.

10. A sample of sodium hydrogencarbonate was tested for purity using the following method. 0.400g of the solid was dissolved in 100.0 cm^3 of water and titrated with 0.200 M hydrochloric acid using methyl orange indicator.

$$NaHCO_{3(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + CO_{2(g)} + H_{2(g)}$$

23.75 cm^3 of acid was required for complete neutralisation. [Ar's: Na = 23, H = 1, C = 12, O = 16]

a) Calculate the moles of acid used in the titration and the moles of sodium hydrogencarbonate titrated.

b) Determine the mass of sodium hydrogen carbonate titrated and hence the purity of the sample.

Moles Test

No.3

To Pass the Mole Driving Test and throw away your **M**- plate you will need to achieve a score of greater than 70%. Each question is equally weighted (5%).

Relative Atomic Masses:
Hydrogen (H) = 1, Carbon (C) = 12, Nitrogen (N) = 14, Oxygen (O) = 16, Sodium (Na) = 23, Magnesium (Mg = 24, Silicon (Si) = 28, Phosphorus(P) = 31, Sulfur (S) = 32, Chlorine (Cl) = 35.5, Potassium (K) = 39, Titanium (Ti) = 48, Barium (Ba) = 137

Molar Volume: 22,4000 cm^3 at STP (273.15 K and 1 atm)

Avodagdro's Number: 6.02 x 10^{23} mol^{-1}

1. One isotope of sodium has a relative mass of 23.

Calculate the mass, in grams, of a single atom of this isotope of sodium.

2. A compound contains 12.8% carbon and 2.13% Hydrogen, the rest being Bromine. The relative molecular mass of the compound is 188. Calculate the empirical formula and the molecular formula of the compound.

3. Calculate the mass of phosphorus required to make 200 g of phosphine, PH_3, by the reaction:

$$P_{4(s)} + 3NaOH_{(aq)} + 3H_2O_{(l)} \rightarrow 3NaH_2PO_{4(aq)} + PH_{3(g)}$$

4. A student heats 5.29g of $Sr(NO_3)_2$ and collects the gas.

$$2Sr(NO_3)_{2(s)} \rightarrow 2SrO(s) + 4NO_{2(g)} + O_{2(g)}$$

Calculate the volume of gas, in dm^3, obtained by the student at STP. Molar mass of $Sr(NO_3)_2$ = 211.6 g mol^{-1}.

5. A student heats 12.41g of hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot 5H_2O$, to remove the water of crystallisation. A white powder called anhydrous sodium thiosulfate forms.

a) What is the relative formula mass of $Na_2S_2O_3 \cdot 5H_2O$?

b) Calculate the expected mass of anhydrous sodium thiosulfate that forms.

6. The metal titanium is obtained by the Kroll process in which titanium ore is converted into titanium chloride and then reduced using magnesium in an atmosphere of argon.

$$2Mg_{(s)} + TiCl_{4(l)} \rightarrow 2MgCl_{2(aq)} + Ti_{(s)}$$

In industry 3800 kg of titanium chloride are added to 1500 kg of magnesium. Calculate the maximum mass of titanium produced in this reaction.

7. In the exhaust stroke the gaseous products escape. Calculate the volume of carbon dioxide produced, at STP, if 1 mg of octane, C_8H_{18}, is completely combusted.

a) Calculate the number of moles of octane in 1 mg.

b) Calculate the number of moles and hence the of carbon dioxide produced.

8. The carbonate of metal **M** has the formula M_2CO_3. The equation for the reaction of this carbonate with hydrochloric acid is given below.

$$M_2CO_{3(s)} + 2HCl_{(aq)} \rightarrow 2MCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

A sample of M_2CO_3 of mass 0.394 g, required the addition of 21.7 cm^3 of a 0.263 M solution of hydrochloric acid for complete reaction.

a) Calculate the number of moles of hydrochloric acid used.

b) Deduce the relative molecular mass of M_2CO_3 and hence the identity of M

9. A different solution of ammonia was reacted with sulphuric acid as shown in the equation below.

$$2NH_{3(aq)} + H_2SO_{4(aq)} \rightarrow (NH_4)_2SO_{4(aq)}$$

In a titration, 25.0 cm^3 of a 1.24 M solution of sulfuric acid required 30.8 cm^3 of this ammonia solution for complete reaction.

Calculate the concentration of ammonia in this solution and the mass of ammonium sulphate in the solution at the end of this titration.

10. Hydrogen can be made by the reaction of hydrochloric acid with magnesium according to the equation:

$$2HCl_{(s)} + Mg_{(s)} \rightarrow MgCl_{2(s)} + H_{2(s)}$$

What mass of hydrogen is formed when 100 cm^3 of hydrochloric acid of concentration 5.0 M reacts with an excess of magnesium?

11. Ammonium nitrate can be prepared by the reaction between ammonia and nitric acid:

$$NH_{3\,(g)} + HNO_{3(aq)} \rightarrow NH_4NO_{3\,(aq)}$$

The concentration of a nitric acid solution is 2.00 M. Calculate the volume of this solution, which would be required to react with exactly 20.0 g of ammonia.

12. The equation below represents the thermal decomposition of $KClO_3$.

$$2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$$

a) Calculate the mass of oxygen which could be produced by the complete decomposition of 1.47 g of $KClO_3$.

b) Calculate the mass of $KClO_3$ required to produce 1.00 dm^3 (at STP) of oxygen.

13. A solution of sodium hydroxide contained 0.250 M. Using phenolphthalein indicator, titration of 25.0 cm^3 of this solution required 22.5 cm^3 of a hydrochloric acid solution for complete neutralisation. Determine the molarity of the HCl

14. When barium nitrate is heated it decomposes as follows:

$$Ba(NO_3)_{2(s)} \rightarrow BaO_{(s)} + 2NO_{2(g)} + ½\ O_{2(g)}$$

a) Calculate the total volume, measured at STP, of gas, which is produced by decomposing 5.00 g of barium nitrate.

b) Calculate the volume of 1.20 M hydrochloric acid which is required to neutralise exactly the barium oxide formed by decomposition of 5.00 g of calcium nitrate. Calcium oxide reacts with hydrochloric acid as follows:

$$CaO_{(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)}$$

15. 1.133 g of silver nitrate was heated in an open tube. The silver residue weighed 0.720 g. During the reaction 0.307 g of nitrogen dioxide was also produced. The rest of the mass loss was due to oxygen. Use the data to write the equation for the reaction.