Level 1-2

1. **State** the formulas for molarity, molality and molar fraction.

   \[
   M = \frac{\text{mol}}{L} \quad m = \frac{\text{mol}}{kg} \quad x_i = \frac{\text{mol of solute}}{\text{mol total}}
   \]

2. **Calculate** which is the fastest of these speeds: 100 km/h; 40 m/s; 0.02 km/s

   \[
   \frac{100 \text{ km}}{\text{h}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{3600 \text{ s}} = 27.8 \text{ m/s} \quad \text{//} \quad \frac{0.02 \text{ km}}{\text{s}} \times \frac{1000 \text{ m}}{1 \text{ km}} = 20 \text{ m/s}
   \]

   \[40 \text{ m/s} > 27.8 \text{ m/s} > 20 \text{ m/s}\]

3. **Draw** a simple parallel circuit that contains a battery, 2 resistors and 2 bulbs. (They do not need to be in a particular order)

   ![Parallel Circuit Diagram](attachment:parallel_circuit.png)

   (Or any variation)

Level 3-4

4. **Formulate** these compounds: ammonium chloride, gold(I) oxide, nitrous acid, strontium hypobromite, methane, Ni(OH)₃, HClO, B₂H₆, Sc₂S₃, K₂Cr₂O₇.

   \[
   \text{NH}_4\text{Cl} \quad \text{Sr} (\text{BrO})_2 \quad \text{HNO}_2 \quad \text{CH}_4 \quad \text{Hypochlorous acid} \quad \text{Potassium dichromate}
   \]

   \[
   \text{Au}_2\text{O} \quad \text{CH}_4 \quad \text{Nickel (III) hydroxide} \quad \text{Diborane (born)} \quad \text{Scandium sulfoide}
   \]

5. Methane reacts with oxygen gas to form carbon dioxide and water. **Write** a balanced equation and **calculate** how many moles of water are produced if we use 2 moles of methane and 4 moles of oxygen.

   \[
   \text{CH}_4 + \frac{1}{2} \text{O}_2 \rightarrow \text{CO}_2 + \frac{2}{x} \text{H}_2\text{O}
   \]

   \[\frac{2 \text{ mol}}{4 \text{ mol}} \quad \frac{1}{2} : 2 = 2 \quad \text{Neither is limiting} \quad x = 4 \text{ mol}\]

6. **Explain** how Bohr’s model of the atom explains atomic emission spectra like the one below.

   ![Bohr’s Model Diagram](attachment:bohrs_model.png)

   Bohr’s model stated that electrons are found in specific energy levels. So when an electron absorbs energy, it can jump up to a higher level. When it drops down again, it releases a specific amount of energy causing a line at a specific colour.
Level 5-6

7. A body moves from rest with a constant acceleration of 8 m/s². Calculate the velocity after 5 s and the distance travelled in the first 5 s.

\[
\begin{align*}
\text{Data} & : \quad \begin{aligned}
S_0 &= 0 \\
V_0 &= 0 \\
T &= 5 \\
a &= 8 \\
\end{aligned} \\
\text{Formula} & : \quad \begin{aligned}
S &= S_0 + (V_0 \cdot t) + \frac{1}{2} a t^2 \\
V &= V_0 + (a \cdot t) \\
\end{aligned} \\
\text{Calculations} & : \quad \begin{aligned}
V_f &= 0 + 8 \cdot 5 = 40 \text{ m/s} \\
S &= 0 + (0 \cdot 5) + \frac{1}{2} \cdot 8 \cdot 5^2 = 100 \text{ m} \\
\end{aligned}
\]

8. A sample of He(g) occupies 15.0 L with a pressure of 856 mmHg when the temperature is 52 ºC. How many grams of He(g) does the sample contain?

Data: atomic mass He=4 g/mol; 1 atm = 760 mmHg; R = 0.082 atm⋅L/K⋅mol

\[
\begin{align*}
\text{Data} & : \quad \begin{aligned}
V &= 15.0 \text{ L} \\
P &= \frac{856 \text{ mmHg}}{760 \text{ mmHg}} = 1.13 \text{ atm} \\
T &= 325 \text{ K} \\
\end{aligned} \\
\text{Formula} & : \quad PV = nRT \quad \rightarrow \quad n = \frac{PV}{RT} \\
\text{Calculations} & : \quad \begin{aligned}
\frac{P V}{R T} &= \frac{1.13 \text{ atm} \cdot 15.0 \text{ L}}{0.082 \text{ atm} \cdot \text{L} / \text{K} / \text{mol} \cdot 325 \text{ K}} \\
n &= 0.636 \text{ mol} \\
\frac{m}{nmol} &= 4 \text{ g/mol} \quad \rightarrow \quad m = n \cdot \frac{m}{nmol} = 0.636 \cdot 4 = 2.54 \text{ g} \\
\end{aligned}
\]

9. Calculate the volume of a 10000 tonne ship that is submerged if the density of seawater is 1030 kg/m³.

\[
\begin{align*}
\text{Data} & : \quad \begin{aligned}
V &= ? \\
M &= 10000 \text{ tonne} = 10000000 \text{ kg} \\
d_{\text{sea}} &= 1030 \text{ kg/m}^3 \\
\end{aligned} \\
\text{Formula} & : \quad F_{\text{upthrust}} = V \cdot d \cdot g \\
\text{Calculations} & : \quad \begin{aligned}
F_{\text{weight}} &= m \cdot g = 98000000 \text{ N} \\
F_{\text{upthrust}} &= F_{\text{weight}} \\
98000000 &= V \cdot 1030 \cdot 9.8 \\
V &= 9710 \text{ m}^3 \\
\end{aligned}
\]

Level 7-8

1. How many grams of acec acid should we dissolve in 250 mL of water in order to change its boiling point up to 101.3 °C?

Data: molecular mass acec acid = 60 g/mol; density of water = 1g/ml. Water \( k_b = 0.512 \)

\[
\frac{\Delta T}{\Delta H} = \frac{60}{250} \quad m = 2.54 \text{ mol/kg}
\]

\[
2.54 = \frac{\text{mol}}{0.250} \quad \text{mol} = 0.635 \quad \text{mm}
\]

\[
0.635 = \frac{\text{mm}}{60} \quad \text{mass} = 38.1 \quad \text{g}
\]

2. An electrolyc cell was set up with an unknown manganese ion solution. It was run for 10 minutes at a current of 4 A and produced a mass of 0.684 g of manganese metal. Calculate the oxidation state of the manganese in solution.

Data: Atomic mass=55; F=96500 C/mol, Common oxidation states of manganese = +2, +6, +7

\[
\text{Data} \quad \text{Formulas} \quad \text{Calculation}
\]

\[
\text{Calculation} = \frac{\text{mm}}{55} \quad \text{F} = 96500 \quad 55 = \frac{1.997 \times 96500}{4.600} + 2
\]

n = 2

Oxidation state is +2

3. The Hindenburg was a large hydrogen(very flammable) filled balloon that caught fire when it came close to the metal landing tower that it was supposed to be anchored to. One theory is that static electricity caused the fire. Explain how.

* Perhaps static charge built up on the balloon as it travelled.
* When it came close to the metal landing tower, electrons surged from one object to the other to balance the charge.
* This “spark” (4 electrons) caused the hydrogen to set on fire.