

CHEM1611 Answers to Problem Sheet 1

1.

liquid mercury	element	ice	molecular compound
neon gas	element	liquid nitrogen	element
milk	mixture	copper pipe	element
blood	mixture	air	mixture
gaseous CO ₂	molecular compound	gaseous oxygen	element
solid sodium	element	brass	mixture

2.

	symbol	protons	neutrons	electrons
(a)	³⁵ ₁₇ Cl	17	18	17
(b)	¹⁹⁷ ₇₉ Au	79	118	79
(c)	⁴⁰ ₂₀ Ca	20	20	20
(d)	⁵¹ ₂₃ V	23	28	23
(e)	¹³³ ₅₅ Cs	55	78	55

3. ²³⁴₉₀Th : the number of neutrons is 234 – 90 = 144.

4. O²⁻, F⁻ and Ne have exactly 10 electrons.

O²⁻ Atomic number 8 → -2 anion has 10e⁻

He Atomic number 2 → 2e⁻

Ar Atomic number 18 → 18e⁻

F⁻ Atomic number 9 → -1 anion has 10e⁻

Sr Atomic number 38 → 38e⁻

S²⁻ Atomic number 16 → -2 anion has 18e⁻

Cl⁻ Atomic number 17 → -1 anion has 18e⁻

O Atomic number 8 → 8e⁻

F Atomic number 9 → 9e⁻

Ne Atomic number 10 → 10e⁻

5. (d) fluorine, chlorine, bromine, iodine

6. **Molecular mass of CH_3NH_2 :**

$$12.01 (\text{C}) + 3 \times 1.01 (\text{H}) + 14.01 (\text{N}) + 2 \times 1.01 (\text{H}) = 31.06 \text{ g mol}^{-1}$$

Number of moles in 1 g:

$$\text{number of moles} = \text{mass} / \text{molar mass} = 1 / 31.06 = 0.03 \text{ mol}$$

Note that the question asks for the number of moles in 1 g. Since this mass is given to only one significant figure, so is the answer.

7. **Molar mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$:**

$$\begin{aligned} &63.55 (\text{Cu}) + 32.07 (\text{S}) + 4 \times 16.00 (\text{O}) + 5 \times [2 \times 1.01 (\text{H}) + 16.00 (\text{O})] \\ &= 249.72 \text{ g mol}^{-1} \end{aligned}$$

Number of moles in 24.9 g of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$:

$$\text{number of moles} = \text{mass} / \text{molar mass} = 24.9 / 249.72 = 0.100 \text{ mol.}$$

1 mol of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ contains 1 mol of copper so,

$$\text{number of moles of copper} = 0.100 \text{ mol}$$

Note that the question gave the mass as 24.9 g – three significant figures. The answer reflects this. The trailing zeros in 0.100 imply that the number is known to three significant figures.

8. **The relative atomic mass of silicon is the weighted average of the masses of its isotopes:**

$$\begin{aligned} &\left(27.97693 \times \frac{92.21}{100} \right) + \left(28.97649 \times \frac{4.70}{100} \right) + \left(29.97376 \times \frac{3.09}{100} \right) \\ &= (25.80) + (1.36) + (0.926) = 28.09 \text{ g mol}^{-1} \end{aligned}$$

The numbers in brackets are given to four, three and three significant figures respectively since this is the precision of the relative abundances in the question. When these are added, the answer is precise to the second decimal place as this is where the point at which each term is known precisely.

9. (a) **As density is given by density (ρ) = $\frac{\text{mass}(\text{m})}{\text{volume}(\text{V})}$.**

The mass of 1.00 L (= 1000 mL) of water is:

$$\text{m} = \rho \times \text{V} = 0.997 \times 1000 = 997 \text{ g}$$

The molar mass of H₂O is:

$$2 \times 1.01 \text{ (H)} + 16.00 \text{ (O)} = 18.02 \text{ g mol}^{-1}$$

Hence, the number of moles in 997 g is:

$$\text{number of moles (n)} = \frac{\text{mass (m)}}{\text{molar mass (M)}} = \frac{997}{18.02} = 55.3 \text{ mol}$$

(b) Concentration is given by:

$$\text{concentration (c)} = \frac{\text{number of moles (n)}}{\text{volume (V)}}$$

From part (a), there are 55.3 mol of water in 1.00 L so the concentration is:

$$c = \frac{55.3}{1.00} = 55.3 \text{ M}$$

(c) Neglecting the small changes in volume and density when NaCl is added to water, a 1.00 M NaCl solution will contain 1.00 mol of Na⁺, 1.00 mol of Cl⁻ and 55.3 mol of H₂O. As the number of molecules (or ions) is directly proportional to the number of moles, the ratio of water molecules: Na⁺ ions : Cl⁻ ions is roughly 55 : 1: 1.