

## Physical Chemistry Fundamentals ANSWERS

Complete the table about these atoms and ions. ✓ correct row

(2)

atom / ion	atomic number	mass number	protons	neutrons	electrons
${}_{15}^{31}\text{P}^{3-}$	15	31	15	16	18
${}_{35}^{81}\text{Br}^{-}$	17	37	35	46	36

2 Convert these quantities into the units shown.

- a)  $25 \text{ cm}^3$  to  $\text{dm}^3$  ✓  $25 \times 10^{-3} = 0.025 \text{ dm}^3$  (1)
- b)  $500 \text{ cm}^3$  to  $\text{m}^3$  ✓  $500 \times 10^{-6} = 5.00 \times 10^{-4} \text{ m}^3$  (1)
- c)  $100 \text{ kPa}$  to  $\text{Pa}$  ✓  $100 \times 10^3 = 1.0 \times 10^5 \text{ Pa}$  (1)
- d)  $89 \text{ mg}$  to  $\text{g}$  ✓  $89 \times 10^{-3} = 0.089 \text{ g}$  (1)
- e)  $-196^\circ\text{C}$  to  $\text{K}$  ✓  $-196 + 273 = 77 \text{ K}$  (1)
- f)  $0.102 \text{ nm}$  to  $\text{m}$  ✓  $0.102 \times 10^{-9} = 1.02 \times 10^{-10} \text{ m}$  (1)

2 a) Explain what the Avogadro constant is.

✓  $6.022 \times 10^{23}$  of something (1)

b) Calculate the number of molecules of water in 90.0 g of water. (Avogadro constant,  $L = 6.022 \times 10^{23} \text{ mol}^{-1}$ )

✓  $\text{moles H}_2\text{O} = \frac{90.0}{18.0} = 5.00$

✓  $\text{molecules H}_2\text{O} = 5.00 \times 6.022 \times 10^{23} = 3.01 \times 10^{24}$  (2)

3 Calculate the relative formula mass ( $M_r$ ) of the following substances.

a)  $\text{O}_2$  ✓  $M_r = 32.0$  (1)

b)  $\text{K}_2\text{SO}_4$  ✓  $M_r = 174.3$  (1)

c)  $\text{Mg}(\text{NO}_3)_2$  ✓  $M_r = 148.3$  (1)

d)  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  ✓  $M_r = 249.6$  (1)

4 Calculate the mass of each of the following.

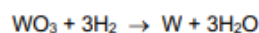
a) 5.00 moles of  $\text{Fe}_2\text{O}_3$  ✓  $5.00 \times 159.6 = 798 \text{ g}$  (1)

b) 0.250 moles of hydrogen ✓  $\text{H}_2$   $0.250 \times 2.0 = 798 \text{ g}$  (1)

c)  $1.50 \times 10^{-4}$  moles of aluminium iodide ✓  $\text{AlI}_3$   $1.50 \times 10^{-4} \times 407.7 = 0.0612 \text{ g}$  (1)

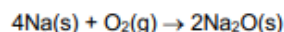
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In a reaction, 115 g of tungsten was formed from 200 g of tungsten oxide. Calculate the percentage yield.



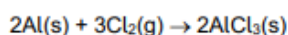
- ✓ moles  $\text{WO}_3 = \frac{200}{231.8} = 0.863$
- ✓ moles  $\text{W} = 0.863$
- ✓ mass  $\text{W} = 0.863 \times 183.8 = 158.6 \text{ g}$
- ✓ % yield =  $\frac{115}{158.6} \times 100 = 72.5\%$  (4)

What mass of oxygen reacts with 2.30 g of sodium?



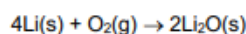
- ✓ moles  $\text{Na} = \frac{2.30}{23.0} = 0.100$
- ✓ moles  $\text{O}_2 = \frac{0.100}{4} = 0.0250$
- ✓ mass  $\text{O}_2 = 0.025 \times 32 = 0.800 \text{ g}$  (3)

Which is the limiting reagent and what mass of aluminium chloride is formed when 1.35 g of aluminium is heated with 4.26 g of chlorine?



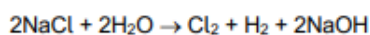
- ✓ moles  $\text{Al} = \frac{1.35}{27.0} = 0.0500$       moles  $\text{Cl}_2 = \frac{4.26}{71.0} = 0.0600$
- ✓ limiting reagent is  $\text{Cl}_2$  as 0.0500 mol of  $\text{Al}$  would need 0.0750 mol of  $\text{Cl}_2$ , but there is only 0.0600 mol
- ✓ moles  $\text{AlCl}_3 = 0.0600 \times \frac{2}{3} = 0.0400$
- ✓ mass  $\text{AlCl}_3 = 0.0400 \times 133.5 = 5.34 \text{ g}$  (4)

Which is the limiting reagent and what mass of lithium oxide is formed when 1.0 g of lithium is heated with 1.3 g of oxygen?



- ✓ moles  $\text{Li} = \frac{1.0}{6.9} = 0.145$       moles  $\text{O}_2 = \frac{1.3}{32.0} = 0.0406$
- ✓ limiting reagent is  $\text{Li}$  as 0.0406 mol of  $\text{O}_2$  would need 0.162 mol of  $\text{Li}$  but there is only 0.145 mol
- ✓ moles  $\text{Li}_2\text{O} = 0.145 \times \frac{1}{2} = 0.0725$
- ✓ mass  $\text{Li}_2\text{O} = 0.0725 \times 29.8 = 2.2 \text{ g}$  (4)

Calculate the percentage atom economy to form chlorine in this reaction.



- ✓ % atom economy =  $\frac{71.0}{2(58.5)+2(18.0)} \times 100$
- ✓ = 46.4% (2)

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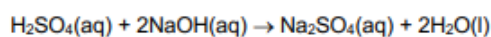
250 cm<sup>3</sup> of aqueous solution contains 2.0 g of dissolved sodium hydroxide. Calculate the concentration of the solution in mol dm<sup>-3</sup>

✓ moles NaOH =  $\frac{2.0}{40.0} = 0.0500$

✓ concentration =  $\frac{0.0500}{\frac{250}{1000}} = 0.200 \text{ mol dm}^{-3}$  (2)

### Titration Calculations

In a titration, it was found that 25.0 cm<sup>3</sup> of 0.150 mol dm<sup>-3</sup> sulfuric acid reacts with 23.58 cm<sup>3</sup> of sodium hydroxide solution. Calculate the concentration of the sodium hydroxide solution in mol dm<sup>-3</sup>.

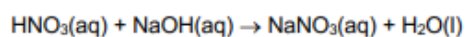


✓ moles H<sub>2</sub>SO<sub>4</sub> =  $\frac{25.0}{1000} \times 0.150 = 0.00375$

✓ moles NaOH =  $2 \times 0.00375 = 0.00750$

✓ concentration NaOH =  $\frac{0.00750}{\frac{23.58}{1000}} = 0.318 \text{ mol dm}^{-3}$  (3)

In a titration, it was found that 25.00 cm<sup>3</sup> of 0.100 mol dm<sup>-3</sup> sodium hydroxide reacts with 26.38 cm<sup>3</sup> of nitric acid. Calculate the concentration of the nitric acid solution in mol dm<sup>-3</sup>.



✓ moles NaOH =  $\frac{25.0}{1000} \times 0.100 = 0.00250$

✓ moles HNO<sub>3</sub> = 0.00250

✓ concentration HNO<sub>3</sub> =  $\frac{0.00250}{\frac{26.38}{1000}} = 0.0945 \text{ mol dm}^{-3}$  (3)