

Reacting mass problems 2

Remember

Check with your teacher whether you should involve moles in your calculations, or whether you may use the quick check method instead. Here is an example of this method.

5.40 g of aluminium reacts completely with oxygen: $4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$

Calculate the mass of aluminium oxide formed in the reaction. Relative masses: Al = 27, $\text{Al}_2\text{O}_3 = 102$

$$\text{mass of Al}_2\text{O}_3 = \text{mass of Al} \times \frac{\text{total relative mass of Al}_2\text{O}_3}{\text{total relative mass of Al}} = 5.40 \times \frac{(2 \times 102)}{(4 \times 27)} = 10.2 \text{ g}$$

Questions

1. Sodium reacts with oxygen to form sodium oxide: $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$

Calculate the maximum mass of sodium oxide that can be formed from 0.46 g of sodium.

2. Ammonia is manufactured using the Haber process: $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$

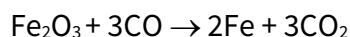
Calculate the mass of ammonia formed if nitrogen reacts completely with 480 g of hydrogen.

[Note: the double-headed arrow \rightleftharpoons shows that the reaction is reversible. You can ignore it here.]

3. Copper(II) oxide can be reduced by heating with carbon: $2\text{CuO} + \text{C} \rightarrow 2\text{Cu} + \text{CO}_2$

Calculate the mass of carbon needed to react completely with 7.95 g of copper(II) oxide.

4. Iron is manufactured in a huge industrial furnace. One of the reactions that happens in the blast furnace involves iron(III) oxide and carbon monoxide:



(a) Calculate the mass of iron(III) oxide needed to produce 112 g of iron in this reaction.

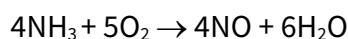
(b) Use your answer to part (a) to calculate the mass of iron that can be made from 320 tonnes of iron(III) oxide.

(c) You can calculate the percentage purity of a substance using this equation:

$$\% \text{ purity} = \frac{\text{actual mass of substance obtained}}{\text{expected mass of substance obtained}} \times 100$$

Iron ore is impure iron(III) oxide. A blast furnace produces 168 tonnes of iron from 320 tonnes of an iron ore. Use your answer to part (b) to calculate the percentage purity of this iron ore.

5. Nitric acid is produced from ammonia using the Ostwald process. The first stage of this process involves ammonia and oxygen from air:



Calculate the mass of oxygen needed to react completely with 3.4 kg of ammonia.

Use these relative atomic masses.

Element	H	N	C	O	Na	Fe	Cu
A_r	1	14	12	16	23	56	63.5

Reacting mass problems 2 – ANSWERS

1. Sodium reacts with oxygen to form sodium oxide: $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$

Calculate the maximum mass of sodium dioxide that can be formed from 0.46 g of sodium.

$$M_r \text{ of Na}_2\text{O} = (2 \times 23) + 16 = 62$$

$$\text{amount of Na} = \frac{0.46}{23} = 0.02 \text{ mol}$$

Mole ratio Na : Na₂O is 4 : 2 which simplifies to 2 : 1

$$\text{This means that } \frac{0.02}{2} \times 1 = 0.01 \text{ mol of Na}_2\text{O forms}$$

$$\text{Mass of Na}_2\text{O formed} = 0.01 \times 62 = 0.62 \text{ g}$$

2. Ammonia is manufactured using the Haber process: $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$

Calculate the mass of ammonia formed if nitrogen reacts completely with 480 g of hydrogen.

[Note: the double-headed arrow \rightleftharpoons shows that the reaction is reversible. You can ignore it here.]

$$M_r \text{ of H}_2 = 2 \times 1 = 2 \qquad M_r \text{ of NH}_3 = 14 + (3 \times 1) = 17$$

$$\text{amount of H}_2 = \frac{480}{2} = 240 \text{ mol}$$

Mole ratio H₂ : NH₃ is 3 : 2

$$\text{This means that } \frac{240}{3} \times 2 = 160 \text{ mol of NH}_3 \text{ forms}$$

$$\text{Mass of NH}_3 \text{ formed} = 160 \times 17 = 2720 \text{ g}$$

3. Copper(II) oxide can be reduced by heating with carbon: $2\text{CuO} + \text{C} \rightarrow 2\text{Cu} + \text{CO}_2$

Calculate the mass of carbon needed to react completely with 7.95 g of copper(II) oxide.

$$M_r \text{ of CuO} = 63.5 + 16 = 79.5$$

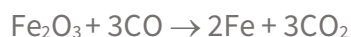
$$\text{amount of CuO} = \frac{7.95}{79.5} = 0.1 \text{ mol}$$

Mole ratio CuO : C is 2 : 1

$$\text{This means that } \frac{0.1}{2} \times 1 = 0.05 \text{ mol is needed}$$

$$\text{Mass of C needed} = 0.05 \times 12 = 0.6 \text{ g}$$

4. Iron is manufactured in a huge industrial furnace. One of the reactions that happens in the blast furnace involves iron(III) oxide and carbon monoxide:



- (a) Calculate the mass of iron(III) oxide needed to produce 112 g of iron in this reaction.

$$M_r \text{ of } \text{Fe}_2\text{O}_3 = (2 \times 56) + (3 \times 16) = 160$$

$$\text{amount of Fe} = \frac{112}{56} = 2 \text{ mol}$$

Mole ratio $\text{Fe}_2\text{O}_3 : \text{Fe}$ is 1 : 2

This means that $\frac{2}{2} \times 1 = 1$ mol of Fe_2O_3 is needed

$$\text{Mass of } \text{Fe}_2\text{O}_3 \text{ needed} = 1 \times 160 = 160 \text{ g}$$

- (b) Use your answer to part (a) to calculate the mass of iron that can be made from 320 tonnes of iron(III) oxide.

$$\text{Mass of iron} = \frac{320 \times 10^6 \text{ g}}{160 \text{ g}} \times 112 = 2.24 \times 10^8 \text{ g} = 224 \text{ tonnes}$$

If answer (a) is incorrect, allow value of $320 \div (\text{answer a}) \times 112$

- (c) Iron ore is impure iron(III) oxide. A blast furnace produces 168 tonnes of iron from 320 tonnes of an iron ore. Use your answer to part (b) to calculate the percentage purity of this iron ore.

$$\% \text{ purity} = \frac{\text{actual mass of substance obtained}}{\text{expected mass of substance obtained}} \times 100 = \frac{168 \text{ tonnes}}{224 \text{ tonnes}} \times 100$$

$$= 75\%$$

If answer (b) is incorrect, allow value of $168 \div (\text{answer b}) \times 100$

5. Nitric acid is produced from ammonia using the Ostwald process. The first stage of this process involves ammonia and oxygen from air:



Calculate the mass of oxygen needed to react completely with 3.4 kg of ammonia.

$$M_r \text{ of } \text{NH}_3 = 14 + (3 \times 1) = 17$$

$$M_r \text{ of } \text{O}_2 = 2 \times 16 = 32$$

$$\text{amount of } \text{NH}_3 = \frac{3.4 \times 10^3}{17} = 200 \text{ mol}$$

Mole ratio $\text{NH}_3 : \text{O}_2$ is 4 : 5

This means that $\frac{200}{4} \times 5 = 250$ mol of O_2 is needed

$$\text{Mass of } \text{O}_2 \text{ needed} = 250 \times 32 = 8\,000 \text{ g (8 kg)}$$