IB Chemistry HL - R2.1

How much? The amount of chemical change

Exercises + Practice questions

Official answers appended at the end

Exercise

Q1. Write balanced chemical equations, including state symbols, for the following reactions:

(a) The decomposition of copper(II) carbonate powder ($CuCO_3$) into copper(II) oxide powder (CuO) and carbon dioxide gas (CO_2).

(b) The combustion of a magnesium strip (Mg) in oxygen gas (O_2) to form magnesium oxide powder (MgO).

(c) The neutralization of sulfuric acid solution (H_2SO_4) with sodium hydroxide solution (NaOH) to form aqueous sodium sulfate (Na_2SO_4) and water (H_2O).

(d) The synthesis of ammonia gas (NH_3) from nitrogen gas (N_2) and hydrogen gas (H_2).

(e) The combustion of methane gas (CH_4) to produce gaseous carbon dioxide (CO_2) and water vapour (H_2O).

Q2. Write balanced chemical equations for the following reactions:

(a) $K + H_2O \rightarrow KOH + H_2$

(b) $C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$

(c) $Cl_2 + KI \rightarrow KCl + I_2$

(d) $CrO_3 \rightarrow Cr_2O_3 + O_2$

(e) $Fe_2O_3 + C \rightarrow CO + Fe$

Q3. Use the same processes to balance the following more difficult examples:

(a) $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$

(b) $NH_3 + O_2 \rightarrow NO + H_2O$

(c) $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO + H_2O$

(d) $H_2O_2 + N_2H_4 \rightarrow N_2 + H_2O + O_2$

(e) $C_2H_7N + O_2 \rightarrow CO_2 + H_2O + N_2$

the validity of these assumptions in the laboratory).

Exercise

Q4. Iron ore can be reduced to iron by the following reaction:

$$Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe + 3H_2O(l)$$

(a) How many moles of Fe can be made from 1.25 moles of Fe_2O_3?

(b) How many moles of H_2 are needed to make 3.75 moles of Fe?

(c) If the reaction yields 12.50 moles of H_2O, what mass of Fe_2O_3 was used up?

Q5. Lighters commonly use butane, C_4H_{10}, as the fuel.

(a) Formulate the equation for the combustion of butane.

(b) Determine the mass of butane that burnt when 2.46 g of water were produced.

Q6. The fuel used in booster rockets for the Space Shuttle is a mixture of aluminium and ammonium perchlorate. The reaction equation is as follows:

$$3Al(s) + 3NH_4ClO_4(s) \rightarrow Al_2O_3(s) + AlCl_3(s) + 3NO(g) + 6H_2O(g)$$

Calculate the mass of NH_4ClO_4 that should be added to this fuel mixture to react completely with every kilogram of Al.

Q7. Limestone is mostly calcium carbonate, $CaCO_3$, but it also contains other minerals. When heated, the $CaCO_3$ decomposes into CaO and CO_2. A sample of 1.605 g of limestone was heated and gave off 0.657 g of CO_2.

(a) Formulate the equation for the thermal decomposition of calcium carbonate.

(b) Determine the percentage mass of $CaCO_3$ in the limestone.

(c) State the assumptions you are making in this calculation.

Q8. How many moles are present in each of the following at STP?

(a) 54.5 dm^3 CH_4

(b) 250.0 cm^3 CO

(c) 1.0 m^3 O_2

Q9. What is the volume of each of the following gases at STP?

(a) 44.00 g N_2

(b) 0.25 mol NH_3

Q10. Pure oxygen gas was first prepared by heating mercury(II) oxide, HgO.

$$2HgO(s) \rightarrow 2Hg(l) + O_2(g)$$

What volume of oxygen, at STP, is released by heating 12.45 g of HgO?

Q11. At STP, which sample contains more molecules, 3.14 dm^3 of bromine, Br_2, or 11.07 g of chlorine, Cl_2?

Q12. Calcium reacts with water to produce hydrogen.

$$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$$

Calculate the volume of hydrogen gas produced, at STP, when 0.200 g of calcium reacts completely with water.

Q13. Dinitrogen oxide, N_2O, is a greenhouse gas produced from the decomposition of artificial nitrate fertilizers. Calculate the volume of N_2O produced from 1.0 g of ammonium nitrate when it reacts, at STP, according to the equation:

$$NH_4NO_3(s) \rightarrow N_2O(g) + 2H_2O(l)$$

Q14. In a titration, a 15.00 cm^3 sample of H_2SO_4 required 36.42 cm^3 of 0.147 mol dm^{-3} NaOH solution for complete neutralization. What was the concentration of the H_2SO_4?

Q15. Gastric juice contains hydrochloric acid, HCl. A 5.00 cm^3 sample of gastric juice required 11.00 cm^3 of 0.0100 mol dm^{-3} KOH for neutralization in a titration. What was the concentration of HCl in this fluid? If we assume a density of 1.00 g cm^{-3} for the fluid, what was the percentage by mass of HCl?

Q16. Sodium sulfate, Na_2SO_4, reacts in aqueous solution with lead nitrate, $Pb(NO_3)_2$, as follows:

$$Na_2SO_4(aq) + Pb(NO_3)_2(aq) \rightarrow PbSO_4(s) + 2NaNO_3(aq)$$

In an experiment, 35.30 cm^3 of a solution of sodium sulfate reacted exactly with 32.50 cm^3 of a solution of lead nitrate. The precipitated lead sulfate was dried and found to have a mass of 1.13 g. Determine the concentrations of the original solutions of lead nitrate and sodium sulfate. State what assumptions are made.

will react, leaving 0.5 moles of CH_4 unreacted at the end of the reaction.

Exercise

Q17. 0.40 moles of magnesium are mixed with 0.20 moles of hydrochloric acid.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Which is correct?

	Limiting reactant	Theoretical yield of H_2 (mol)
A	HCl	0.20
B	Mg	0.40
C	HCl	0.10
D	Mg	0.20

Q18. 0.30 moles of hydrochloric acid are mixed with 0.30 moles of calcium carbonate.

$$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(g) + CO_2(g)$$

Which is correct?

	Limiting reactant	Theoretical yield of CO_2 (mol)
A	HCl	0.30
B	HCl	0.15
C	$CaCO_3$	0.15
D	$CaCO_3$	0.30

Q19. 5 cm^3 of nitrogen are reacted with 20 cm^3 of hydrogen in the reaction:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

Assuming that all volumes are measured at the same temperature and pressure:

(a) What volume of ammonia would you expect to be produced?

(b) What volume of H_2 would remain unreacted?