

Exercise 1

1	18	21	11	41	159.5
2	44	22	164	42	161.4
3	17	23	74	43	170
4	46	24	136	44	53.5
5	28	25	208	45	132
6	64	26	1335	46	117.0
7	80	27	213	47	122.5
8	81	28	342	48	166.0
9	98	29	152	49	74.5
10	63	30	127	50	69.0
11	58.5	31	162.5	51	249.5
12	85	32	400	52	278
13	106	33	223	53	964
14	40	34	239	54	248
15	142	35	685	55	126
16	158	36	331	56	246
17	194	37	278	57	2635
18	100	38	303	58	60
19	166	39	99.0	59	58
20	195	40	134.5	60	122

Exercise 2

1 NaCl	21 BaSO ₄	41 PbCO ₃	61 PCl ₃
2 NaOH	22 AlCl ₃	42 PbO	62 PCl ₅
3 Na ₂ CO ₃	23 Al ₂ O ₃	43 PbO ₂	63 P ₂ O ₃
4 Na ₂ SO ₄	24 Al(OH) ₃	44 PbCl ₂	64 P ₂ O ₅
5 NO ₃ PO ₄	25 Al ₂ (SO ₄) ₃	45 PbCl ₄	65 H ₃ PO ₄
6 KCl	26 CuSO ₄	46 PbS	66 H ₂ SO ₄
7 KBr	27 CuO	47 SnCl ₂	67 HNO ₃
8 KI	28 CuCl ₂	48 SnCl ₄	68 HCl
9 KHCO ₃	29 Cu(NO ₃) ₂	49 FeSO ₄	69 CCl ₄
10 KNO ₂	30 Cu ₂ O	50 FeCl ₂	70 SiCl ₄
11 MgCl ₂	31 CuCl	51 Fe ₂ (SO ₄) ₃	71 SiO ₂
12 Mg(NO ₃) ₂	32 Zn(NO ₃) ₂	52 FeCl ₃	72 SO ₂
13 Mg(OH) ₂	33 ZnCO ₃	53 Fe(OH) ₃	73 SO ₃
14 MgO	34 ZnO	54 Fe(OH) ₂	74 H ₂ S
15 MgCO ₃	35 AgCl	55 NH ₄ Cl	75 Cl ₂ O
16 CaO	36 AgBr	56 (NH ₄) ₂ CO ₃	76 NO ₂
17 CaCl ₂	37 AgI	57 NH ₄ OH	77 NO
18 CaSO ₄	38 AgNO ₃	58 NH ₄ NO ₃	78 CO ₂
19 CaCO ₃	39 Ag ₂ O	59 (NH ₄) ₂ SO ₄	79 CO
20 BaCl ₂	40 Pb(NO ₃) ₂	60 (NH ₄) ₃ PO ₄	80 HOH/H ₂ O

Exercise 3

- 1 Water
- 2 Carbon dioxide
- 3 Ammonia
- 4 Oxygen
- 5 Hydrogen
- 6 Sulphur dioxide (or IV oxide)
- 7 Sulphur trioxide (or VI oxide)
- 8 Hydrogen chloride
- 9 Hydrogen iodide
- 10 Hydrogen fluoride
- 11 Methane
- 12 Hydrogen sulphide
- 13 Hydrogen bromide
- 14 Sulphuric acid
- 15 Nitric acid
- 16 Sodium chloride
- 17 Sodium nitrate
- 18 Sodium carbonate
- 19 Sodium hydroxide
- 20 Sodium sulphate
- 21 Calcium chloride
- 22 Calcium nitrate
- 23 Calcium hydroxide
- 24 Calcium sulphate
- 25 Barium chloride
- 26 Aluminium chloride
- 27 Aluminium nitrate
- 28 Aluminium sulphate
- 29 Iron(II) sulphate
- 30 Iron(II)chloride
- 31 Iron(III) chloride
- 32 Iron(III) sulphate
- 33 Lead(II) oxide
- 34 Lead(IV) oxide
- 35 Lead(II) nitrate
- 36 Lead(II) chloride
- 37 Lead (II) sulphate
- 38 Copper(II) nitrate
- 39 Copper(I) chloride
- 40 Copper(II) chloride
- 41 Copper(II) sulphate
- 42 Zinc chloride
- 43 Silver nitrate
- 44 Ammonium chloride
- 45 Ammonium sulphate
- 46 Ammonium vanadate(V)
- 47 Potassium chlorate(V)
- 48 Potassium iodate
- 49 Sodium chlorate(I)
- 50 Sodium nitrite
- 51 Ethane
- 52 Butane
- 53 Octane
- 54 Ammonium carbonate
- 55 Potassium manganate(VII)
- 56 Potassium chromate(VI)
- 57 Potassium hydrogencarbonate
- 58 Potassium iodide
- 59 Cobalt(II) nitrate
- 60 Potassium astatide

Exercise 4a

1	0.50	26	0.10
2	2.0	27	0.10
3	0.10	28	0.0085
4	5.0	29	0.26
5	20	30	0.104
6	0.010	31	0.20
7	1.0	32	0.082
8	0.22	33	0.050
9	0.0010	34	1.34
10	0.050	35	0.025
11	0.33	36	0.204
12	0.25	37	0.071
13	0.021	38	0.010
14	0.020	39	0.050
15	0.125	40	0.254
16	0.020	41	0.0125
17	0.167	42	0.152
18	1.0	43	0.10
19	0.046	44	0.053
20	0.020	45	0.0043
21	0.0010	46	0.036
22	0.25	47	0.266
23	0.02	48	0.024
24	0.0025	49	0.025
25	0.20	50	1.574

Exercise 4b

- | | | | |
|----|---------|----|---------|
| 1 | 36 g | 26 | 14.95 g |
| 2 | 132 g | 27 | 76.2 g |
| 3 | 47.6 g | 28 | 10.03 g |
| 4 | 23 g | 29 | 17.82 g |
| 5 | 33.6 g | 30 | 145.2 g |
| 6 | 40.96 g | 31 | 2.925 g |
| 7 | 240 g | 32 | 12.25 g |
| 8 | 81 g | 33 | 21.4 g |
| 9 | 1.152 g | 34 | 745 g |
| 10 | 9.45 g | 35 | 0.069 g |
| 11 | 26.3 g | 36 | 49.9 g |
| 12 | 59.5 g | 37 | 27.8 g |
| 13 | 11.66 g | 38 | 4.82 g |
| 14 | 80.0 g | 39 | 9.92 g |
| 15 | 127.8 g | 40 | 302.4 g |
| 16 | 7.9 g | 41 | 756.5 g |
| 17 | 34.92 g | 42 | 39.53 g |
| 18 | 90 g | 43 | 10.2 g |
| 19 | 249 g | 44 | 11.6 g |
| 20 | 23.4 g | 45 | 9.76 g |
| 21 | 12.2 g | 46 | 4.34 g |
| 22 | 672.4 g | 47 | 9.59 g |
| 23 | 0.296 g | 48 | 41.0 g |
| 24 | 13.6 g | 49 | 304 g |
| 25 | 43.68 g | 50 | 1397 g |

Exercise 4c

- | | | | |
|----|------------------------|----|------------------------|
| 1 | 24000 cm ³ | 11 | 134.4 cm ³ |
| 2 | 2400 cm ³ | 12 | 216 cm ³ |
| 3 | 12000 cm ³ | 13 | 960 cm ³ |
| 4 | 48000 cm ³ | 14 | 2952 cm ³ |
| 5 | 2880 cm ³ | 15 | 55.2 cm ³ |
| 6 | 81600 cm ³ | 16 | 192000 cm ³ |
| 7 | 2640 cm ³ | 17 | 0.24 cm ³ |
| 8 | 96 cm ³ | 18 | 144000 cm ³ |
| 9 | 240000 cm ³ | 19 | 182.4 cm ³ |
| 10 | 10800 cm ³ | 20 | 72000 cm ³ |

Exercise 4d

- | | | | |
|----|------------|----|--------------|
| 1 | 0.0083 mol | 11 | 0.0292 mol |
| 2 | 0.0208 mol | 12 | 0.2333 mol |
| 3 | 0.0416 mol | 13 | 0.0917 mol |
| 4 | 0.0533 mol | 14 | 0.0088 mol |
| 5 | 0.0098 mol | 15 | 0.0333 mol |
| 6 | 0.0094 mol | 16 | 0.0033 mol |
| 7 | 0.0106 mol | 17 | 0.000080 mol |
| 8 | 0.0033 mol | 18 | 0.8333 mol |
| 9 | 0.0833 mol | 19 | 0.0175 mol |
| 10 | 0.10 mol | 20 | 0.0375 mol |

Exercise 4e

- | | | | |
|----|---------|----|---------|
| 1 | 0.367 g | 11 | 0.875 g |
| 2 | 0.354 g | 12 | 10.27 g |
| 3 | 1.166 g | 13 | 2.38 g |
| 4 | 5.333 g | 14 | 0.263 g |
| 5 | 0.78 g | 15 | 1.217 g |
| 6 | 0.763 g | 16 | 0.270 g |
| 7 | 0.757 g | 17 | 0.011 g |
| 8 | 0.233 g | 18 | 38.33 g |
| 9 | 0.167 g | 19 | 0.683 g |
| 10 | 3.20 g | 20 | 1.05 g |

Exercise 4f

- | | | | |
|----|-------------------------|----|-----------------------|
| 1 | 1091 cm ³ | 11 | 56000 cm ³ |
| 2 | 7059 cm ³ | 12 | 30545 cm ³ |
| 3 | 8571 cm ³ | 13 | 20308 cm ³ |
| 4 | 7500 cm ³ | 14 | 16000 cm ³ |
| 5 | 702 cm ³ | 15 | 5260 cm ³ |
| 6 | 670 cm ³ | 16 | 2370 cm ³ |
| 7 | 3380 cm ³ | 17 | 375 cm ³ |
| 8 | 30000 cm ³ | 18 | 12000 cm ³ |
| 9 | 2400000 cm ³ | 19 | 26526 cm ³ |
| 10 | 180000 cm ³ | 20 | 77143 cm ³ |

Exercise 4g

1	160	11	34
2	64	12	17
3	80	13	38
4	71	14	28
5	2.0	15	44
6	28	16	32
7	30	17	211
8	58	18	36.5
9	32	19	81
10	28	20	128

Exercise 5

Section (a)

1	CaCO ₃	4	N ₂ H ₄ S ₂ O ₈
2	Na ₂ SO ₄	5	P ₄ O ₁₀
3	Na ₂ S ₂ O ₃	6	C ₂ H ₄ O ₂ - CH ₃ COOH
4	PbO	7	C ₄ H ₁₀
5	Pb ₃ O ₄	8	Fe ₂ O ₃
6	H ₃ PO ₃	9	H ₂ S ₂ O ₈
7	H ₂ SO ₃	10	C ₆ H ₆
8	CH ₄		
9	C ₃ H ₈		
10	HO (giving H ₂ O ₂)		
11	H ₄ N ₂ O ₃ (NH ₄ NO ₃)		
12	FeSO ₁₁ H ₁₄ (FeSO ₄ - 7H ₂ O)		

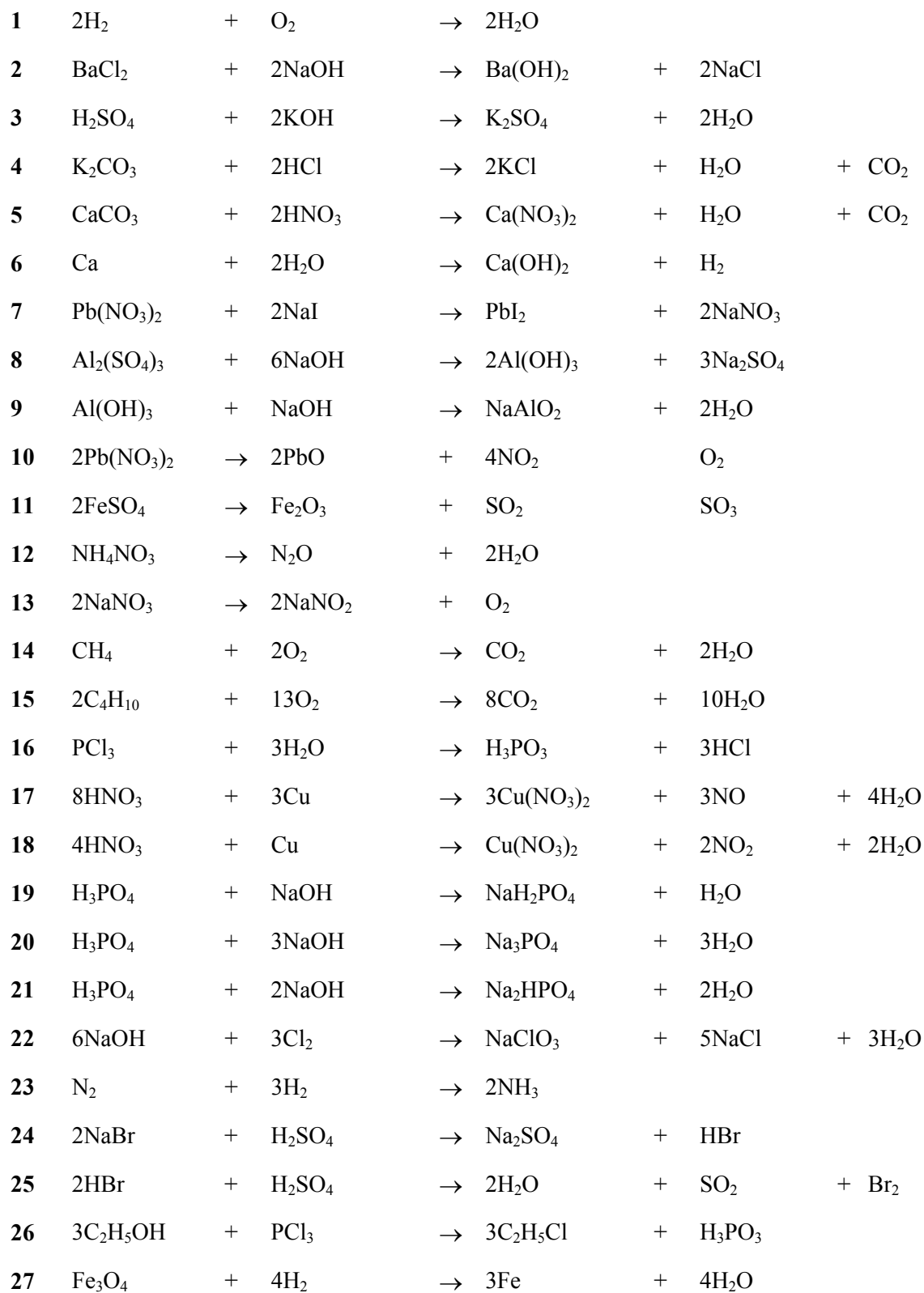
Section (b)

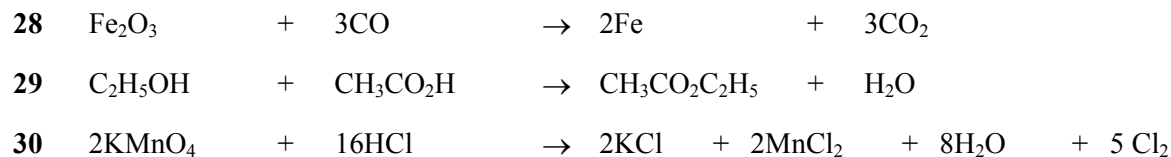
1	C ₂ H ₄		
2	C ₃ H ₆		
3	P ₂ I ₄		

Section (c)

1	PbO
2	KO ₂
3	C ₂ H ₂
4	AlCl ₃
5	CH ₄
6	yes
7	CuSO ₄ · 5H ₂ O
8	PCl ₅ , PCl ₃ , Cl ₂

Exercise 6a





Exercise 6b

1 Hydrogen is not H but H₂, which gives



2 Since the valency of lead is 2 not 1 lead nitrate is not PbNO₃ but Pb(NO₃)₂ and also lead chloride is PbCl₂



3 Calcium hydroxide is Ca(OH)₂



4 This does not balance.



5 A magnesium compound cannot give a calcium compound!

6 Ozone O₃ is not produced by heating a nitrate O₂ is.

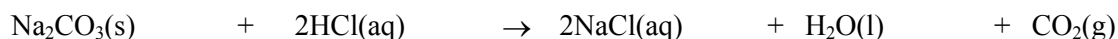


7 This reaction does not take place and so no equation can be written.

8 Aluminium has a valency of 3 not 2 as in this equation.

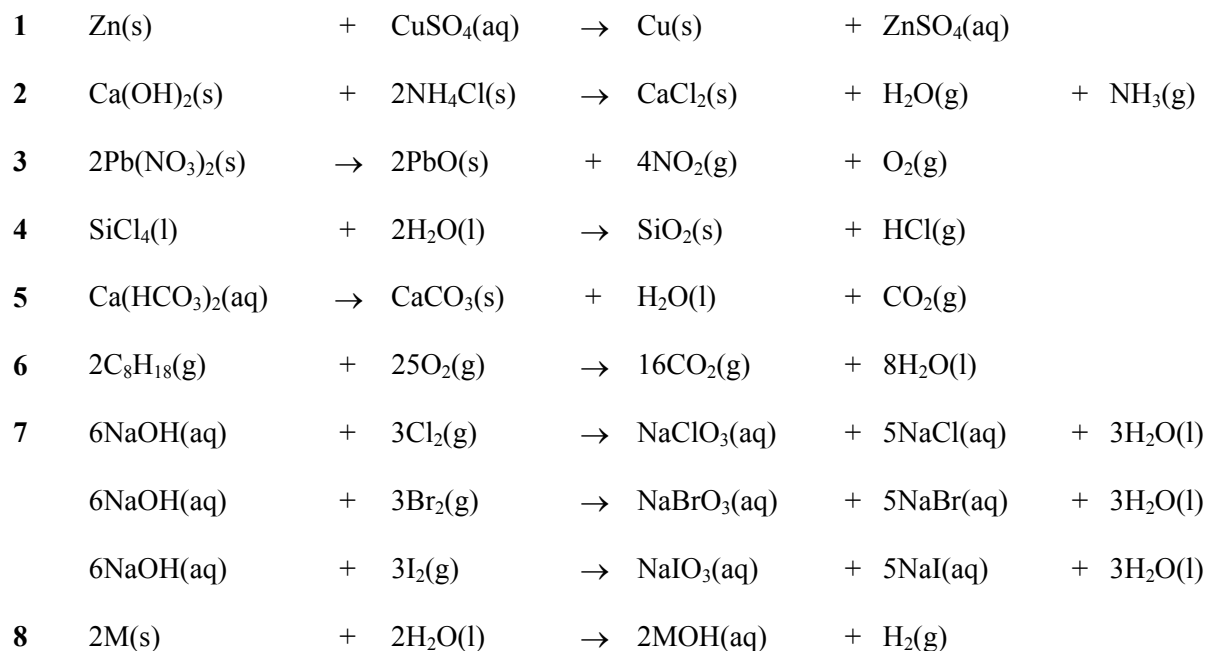


9 Sodium has a valency of 1 not 2 as in this equation

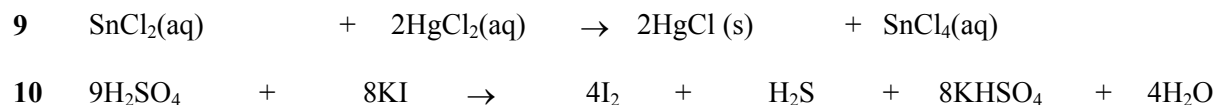


10 Silver chloride is not soluble in water. Thus the AgCl needs a (s) symbol

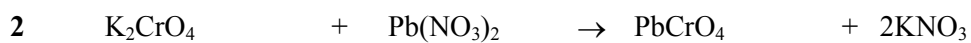
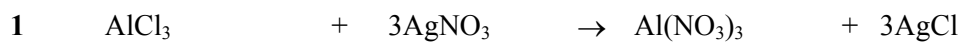
Exercise 6c



Where M = Li, Na, K, Rb or Cs



Exercise 7



4 i) 1 mole

ii) 2 moles

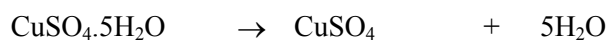
iii)



iv) 75 cm^3

5 $x = 3$

6 $x = 5$



9 It is



Exercise 8

- 1 11.2 g
- 2 21.6 g
- 3 0.682 g of ethanoic acid and 0.523 g of ethanol
- 4 143 tonnes
- 5 14.5 g
- 6 8.0 g of sodium hydroxide, 9.75 g of copper hydroxide
- 7 12000 cm³
- 8 54.7 g of calcium nitrate, 8.0 dm³ of carbon dioxide
- 9 6 dm³ total (4.8 dm³ of nitrogen dioxide and 1.2 dm³ of oxygen)
- 10 $\text{Mg} + \text{H}_2\text{SO}_4 + 7\text{H}_2\text{O} \rightarrow \text{Mg SO}_4 \cdot 7\text{H}_2\text{O} + \text{H}_2$
41.0 g
- 11 31.9 g
- 12 324.3 g
- 13 5.11 g of ethanol, 2.67 dm³ of carbon dioxide
- 14 (i) 12.30 g of zinc hydroxide
(ii) 9.12 g of aluminium hydroxide
(iii) 9.67 g of magnesium hydroxide
- 15 0.600 dm³
- 16 0.100 g
- 17 2.94 g of sodium chloride, 1.065 g of sodium chlorate(v)
- 18 4.15×10^6 dm³ of nitrogen, 12.5×10^6 dm³ of hydrogen
- 19 63 tonnes of nitric acid, 4.8×10^7 dm³ of oxygen
- 20 2198 g of calcium carbonate, 4.395 dm³ of 10M HCl

Exercise 9

Section (a)

1	20cm ³ O ₂	10cm ³ CO ₂	20cm ³ H ₂ O (g)
2	30cm ³ O ₂	20cm ³ CO ₂	20cm ³ H ₂ O (g)
3	25cm ³ O ₂	20cm ³ CO ₂	10cm ³ H ₂ O (g)
4	125cm ³ O ₂	80cm ³ CO ₂	90cm ³ H ₂ O (g)
5	30cm ³ H ₂	20cm ³ NH ₃	

Section (b)

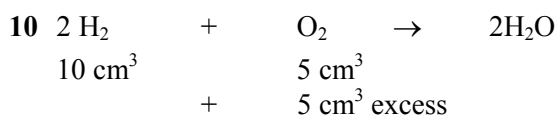
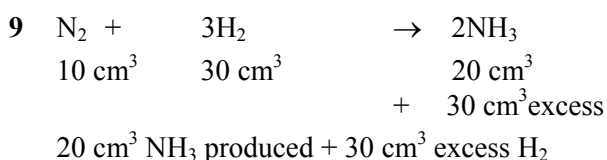
- 500cm³ O₂ (2NO + O₂ → 2NO₂)
- 375cm³ air (2SO₂ + O₂ → 2SO₃)
- 2500cm³ NH₃ needed $\frac{5}{4} \times 2500 = 3125\text{cm}^3$ O₂ → 15625cm³ air
- 6.5 x 24000cm³ = 156m³
- 24000cm³

6 Final volume = 20cm³ (10cm³ CO₂ + 10 cm³ unused O₂)

7 Final volume = 77.5cm³ (40cm³ CO₂ + 37.5cm³ used O₂)

- 8 This time the CH₄ is in excess. We must assume that CO₂ is produced (not CO or C)!

Final volume = 60 cm³ (30 cm³ CO₂ + 30 cm³ CH₄)



Final volume = 5 cm³ (all excess O₂)

Exercise 10

- 1 $\text{Pb}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Pb}(\text{OH})_2(\text{s})$
- 2 $\text{Al}^{3+}(\text{aq}) + 3\text{OH}^{-}(\text{aq}) \rightarrow \text{Al}(\text{OH})_3(\text{s})$
- 3 $\text{Al}(\text{OH})_3(\text{s}) + \text{OH}^{-}(\text{aq}) \rightarrow \text{AlO}_2^{-}(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- 4 $\text{Cl}_2(\text{g}) + 6\text{OH}^{-}(\text{aq}) \rightarrow \text{ClO}_3^{-}(\text{aq}) + 5\text{Cl}^{-}(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$
- 5 $2\text{S}_2\text{O}_3^{2-}(\text{aq}) + \text{I}_2(\text{s}) \rightarrow \text{S}_4\text{O}_6^{2-}(\text{aq}) + 2\text{I}^{-}(\text{aq})$
- 6 $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$
- 7 $\text{CO}_3^{2-}(\text{s}) + 2\text{H}^{+}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
- 8 $\text{Zn}(\text{s}) + 2\text{H}^{+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{H}_2(\text{g})$
- 9 $\text{Zn}(\text{s}) + \text{Pb}^{2+}(\text{aq}) \rightarrow \text{Pb}(\text{s}) + \text{Zn}^{2+}(\text{aq})$
- 10 $\text{H}^{+}(\text{aq}) + \text{OH}^{-}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
- 11 $\text{Mg}(\text{s}) + 2\text{H}^{+}(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g})$
- 12 $\text{CO}_3^{2-}(\text{s}) + 2\text{H}^{+}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
- 13 $\text{CuO}(\text{s}) + 2\text{H}^{+}(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- 14 $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$
- 15 $\text{Ag}^{+}(\text{aq}) + \text{Cl}^{-}(\text{aq}) \rightarrow \text{AgCl}(\text{s})$
- 16 $\text{Zn}(\text{s}) + 2\text{Ag}^{+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{Ag}(\text{s})$
- 17–20 $2\text{OH}^{+}(\text{aq}) + \text{OH}^{-}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$

In every case the reaction is the same

Exercise 11a

- | | | | |
|----|---------------|----|-----------------------------|
| 1 | 0.025 moles | 19 | 0.079 g |
| 2 | 0.025 moles | 20 | 0.828 g |
| 3 | 0.0625 | 21 | 0.1 mol dm ⁻³ |
| 4 | 0.005 moles | 22 | 1.0 mol dm ⁻³ |
| 5 | 0.025 moles | 23 | 0.03 mol dm ⁻³ |
| 6 | 0.025 moles | 24 | 0.1 mol dm ⁻³ |
| 7 | 0.0125 moles | 25 | 0.03 mol dm ⁻³ |
| 8 | 0.01 moles | 26 | 0.04 mol dm ⁻³ |
| 9 | 0.00125 moles | 27 | 0.40 mol dm ⁻³ |
| 10 | 0.005 moles | 28 | 0.40 mol dm ⁻³ |
| 11 | 0.9125 g | 29 | 0.152 mol dm ⁻³ |
| 12 | 1.463 g | 30 | 0.0102 mol dm ⁻³ |
| 13 | 2 g | 31 | 0.01 mol dm ⁻³ |
| 14 | 1.70 g | 32 | 0.2 mol dm ⁻³ |
| 15 | 5.2 g | 33 | 0.02 mol dm ⁻³ |
| 16 | 0.98 g | 34 | 0.005 mol dm ⁻³ |
| 17 | 0.08 g | 35 | 0.417 mol dm ⁻³ |
| 18 | 0.97 g | | |

Exercise 11b

- | | | | |
|----|-----------------------------|----|---|
| 1 | 0.168 mol dm ⁻³ | 16 | 3.0 |
| 2 | 0.136 mol dm ⁻³ | 17 | 0.02 mol dm ⁻³ |
| 3 | 0.118 mol dm ⁻³ | 18 | 50 cm ³ |
| 4 | 1.0 mol dm ⁻³ | 19 | 50 cm ³ |
| 5 | 0.12 mol dm ⁻³ | 20 | 25 cm ³ |
| 6 | 0.040 mol dm ⁻³ | 21 | 0.359 g |
| 7 | 0.0080 mol dm ⁻³ | 22 | 1.0 g |
| 8 | 0.010 mol dm ⁻³ | 23 | 240 cm ³ |
| 9 | 0.10 mol dm ⁻³ | 24 | 0.12 g Mg
120 cm ³ H ₂ |
| 10 | 0.40 mol dm ⁻³ | 25 | 480 cm ³ |
| 11 | 0.050 mol dm ⁻³ | | |
| 12 | 0.167 mol dm ⁻³ | | |
| 13 | 2.26 g dm ⁻³ | | |
| 14 | 0.099 mol dm ⁻³ | | |
| 15 | 1.755 g dm ⁻³ | | |