Question 1 (3 marks)

a)

Molar mass KBr = 39.1 + 79.9 = 119.0 g/mol

*Moles = 15.0 g / 119.0 g/mol = 0.12605 mol → **0.126 mol** (3 sig figs)*

Volume = 0.500 L

*Concentration = 0.126 mol / 0.500 L = **0.252 mol/L***

b)

*% (m/v) = (15.0 g / 500 mL) × 100 = 3.00% **(m/v)***

c)

15.0 g = 15000 mg

*ppm = 15000 mg / 0.5 L = 30000 mg/L = **3.00×10^4 ppm***

Question 2 (8 marks)

a)

$AgNO_3$ (aq)

b)

$2AgNO_3(aq) + CaCl_2(aq) \rightarrow 2AgCl(s) + Ca(NO_3)_2(aq)$

c)

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

d) i.

Moles PbI_2 = 6.60 g / 461.0 g/mol = 0.0143 mol

ii.

Moles KI = 2 × 0.0143 mol = 0.0286 mol

Volume = 0.0250 L

Concentration KI = 0.0286 mol / 0.0250 L = 1.14 mol/L

Question 3 (13 marks)

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

a) i. Moles of gases at SLC

At SLC 1 mol gas = 24.8 L

- *Moles H_2 = 50.0 L / 24.8 L/mol = 2.02 mol (3 sig figs)*
- *Moles N_2 = 20.0 L / 24.8 L/mol = 0.806 mol*

ii. Limiting reagent

Balanced ratio N_2:H_2 = 1:3
For 0.806 mol N_2, required H_2 = 0.806 × 3 = 2.42 mol
Available H_2 = 2.02 mol < 2.42 mol , hence, H_2 is limiting reagent

Excess N_2 remaining
N_2 reacted = H_2/3 = 2.02 / 3 = 0.674 mol
N_2 leftover = 0.806 - 0.674 = 0.132 mol

iii. Volume NH_3 formed

From balanced equation: 3 mol H_2 → 2 mol NH_3
Moles NH_3 formed = (2/3) × moles H_2 = (2/3) × 2.02 = 1.35 mol
Volume NH_3 = 1.35 mol × 24.8 L/mol = 33.5 L

b) Hydrocarbon in 40.0 L at 25°C and 2000 kPa weighing 3.6 kg

Use ideal gas law:
PV = nRT
P = 2000 kPa = 2.00 × 10^6 Pa
V = 40.0 L = 0.0400 m^3
R = 8.314 J/mol·K
T = 25 + 273 = 298 K

n = PV / RT = (2.00×10^6 × 0.0400) / (8.314 × 298) = 32.3 mol

Molar mass = mass / moles = 3600 g / 32.3 mol = 111.5 g/mol

This corresponds closely to C_8H_{18} (octane), molar mass of approximately 114 g/mol

c) Propane combustion

C_3H_8 + 5O_2 → 3CO_2 + 4H_2O (l)

Volume propane = 5.00 × 10^3 L (SLC)

At SLC, volume ratio = mole ratio.

Propane volume = 5.00 × 10^3 L → moles proportional

CO_2 produced = 3 × propane volume / 1 = 3 × 5.00 × 10^3 = 1.5 × 10^4 L
H_2O is liquid → ignore gaseous volume

*Total greenhouse gases = CO_2 only = **1.5 × 10^4 L***

Question 4 (11 marks)

a) Ionisation of sulfuric acid (diprotic, full ionisation):

$H_2SO_4(aq) + 2H_2O(l) \rightarrow 2H_3O^+(aq) + SO_4^{2-}(aq)$

1-----mark for balanced species and charge
1-----mark for correct states.

b) Neutralisation of carbonic acid and NaOH (no states):

$H_2CO_3 + 2NaOH \rightarrow Na_2CO_3 + 2H_2O$

c) Explanation

1-----mark Strong acid (H_2SO_4) fully ionises in water, releasing all H^+ ions, leading to high conductivity and low pH.

1-----mark Weak acid (H_2CO_3) partially ionises, releasing fewer H^+ ions, so it has higher pH and weaker acidity.

d) Dilution of sulfuric acid

i. *$C_1V_1 = C_2V_2 \rightarrow C_2 = (C_1V_1)/V_2$*
$C_1 = 0.200$ M, $V_1 = 50.0$ mL, $V_2 = 200$ mL
$C_2 = (0.200 \times 50.0) / 200 = 0.0500$ M

ii. pH calculation:

Each H_2SO_4 molecule produces 2 H^+ ions → $[H^+] = 2 \times 0.0500 = 0.100$ M

*pH = $-\log[H^+] = -\log(0.100) =$ **1.00***

Question 5 (5 marks)

$Mg + O_2 \rightarrow MgO$

a) Moles magnesium:

Mass Mg = 5.40 g
Molar mass Mg = 24.3 g/mol
*Moles Mg = 5.40 / 24.3 = **0.222 mol***

b) Moles oxygen atoms:

Mass increase = 8.99 - 5.40 = 3.59 g O
Molar mass O = 16.0 g/mol
Moles O atoms = 3.59 / 16.0 = ***0.224 mol***

c) Empirical formula:

Moles Mg = 0.222
Moles O = 0.224

Ratio ≈ 1 : 1 → Empirical formula is ***MgO***