1. (a) Forward and reverse reactions at same rate ✓

Achievable from either direction ✓, requires closed system ✓

concentrations of reactants and products are constant ✓

max: [2]

(b) (i) $K_c = \frac{[\ CH_3OH(g)\ ]}{[\ CO(g)\ ]\ [\ H_2(g)\ ]^2}$ ✓✓ *1 mark for top; 1 mark for bottom*

[2]

(ii) $K_c = \frac{(2.6 \times 10^{-5})}{(3.1 \times 10^{-3})\ (2.4 \times 10^{-2})^2}$ ✓ = 14.6 ✓ ($dm^6\ mol^{-2}$)

[2]

(c) (i) *Why did the equilibrium move to the right*

fewer molecules on right ✓

reaction relieves increase in pressure ✓

[2]

(ii) *What is the effect, if any, on K_c*

K_c stays same ✓

[1]

(iii) *Rate changes*

Rate increases ✓

Increased collisions/more concentrated ✓

Rates initially forward faster than reverse ✓

At equilibrium, rates same ✓

[4]

(d) (i) K_c decreases so products decrease/reactants increase ✓

Therefore equilibrium moves to the left/to endothermic side ✓

2nd mark dependent on first.

[2]

(ii) ΔH is negative because of equilibrium change in **(i)** ✓

Mark consequential on (i)

[1]

(iii) Partial pressure decreases because less CH_3OH is now present ✓

[1]

[Total: 17]

2. **(a)** **(i)** $m(NH_4NO_3)$ = 80 ✓

moles N_2O = moles NH_4NO_3 = 100/80 = 1.25 mol ✓

mass N_2O = 1.25 x (28 + 16) = 55 g ✓

[3]

(ii) nitrogen in NH_4^+: –3 ⟶ +1 / increases by 4 ✓

nitrogen in NO_3^-: +5 ⟶ +1 / decreases by 4 ✓

[2]

(b) **(i)** 1st order has a constant half life ✓

Evidence from graph, either drawn or stated below with 2 half lives ✓

half life approx 52 s✓

[3]

(ii) rate = $k[N_2O(g)]$ ✓

[1]

(iii) evidence of tangent on graph ✓

rate = 0.00524 ✓ mol dm^{-3} s^{-1}

(allow ±0.005 : i.e. values in range 0.00475 – 0.00575 mol dm^{-3} s^{-1})

[2]

(iv) 0.00524 (ans to (ii)) = k x 0.400

k = 0.0131 ✓ s^{-1} ✓

[2]

(v) rate determining step involves 1 molecule of N_2O ✓

equation shows 2 mol N_2O reacting ✓

[2]

(c) Increases the pressure/rate increases ✓

Gives out heat ✓

Forms oxygen ⟶ more efficient combustion ✓

moles of products > moles of reactants ✓

[2 max]

[Total: 17]

3. (a)

Acid is a proton/H^+ donor ✓

Base is a proton/H^+ acceptor ✓

Conjugate acid has H^+ more than conjugate base ✓

Equation showing acid-base pairs ✓

2 acid-base pairs labelled correctly ✓

Dilute acid has small number of moles dissolved per volume ✓

Weak acid has partial dissociation ✓

[7]

Quality of Written Communication

At least **two** complete sentences that are legible and where the spelling, punctuation and grammar allow the meaning to be clear. At least one equation shown. ✓

[1]

(b) (i)

$$K_a = \frac{[H^+(aq)]\,[CN^-(aq)]}{[HCN(aq)]}$$ ✓

[1]

(ii)

$$K_a = \frac{[H^+(aq)]^2}{[HCN(aq)]} \qquad \therefore 4.9 \times 10^{-10} = \frac{[H^+(aq)]^2}{0.010}$$ ✓

$[H^+(aq)] = \sqrt{\{(4.9 \times 10^{-10}) \times (0.010)\}} = 2.2 \times 10^{-6}\ \text{mol dm}^{-3}$ ✓

$pH = -\log[H^+(aq)] = -\log 2.2 \times 10^{-6} = 5.65/5.66/5.7$ ✓

(accept calculator value)

[3]

[Total: 12]

4. (a) (i)

	C	:	H	:	O
=	66.7/12	:	11.1/1	:	22.2/16 ✓
=	5.56	:	11.1	:	1.39
=	4	:	8	:	1

empirical formula = C_4H_8O ✓

48 + 8 + 16 = 72 which is half of M_r

Therefore molecular formula = $C_8H_{16}O_2$ ✓

Structural formula = $CH_3(CH_2)_6COOH$ ✓

[4]

(ii) caprylic acid is a longer molecule/contains more electrons ✓

caprylic acid has more van der Waals forces between molecules ✓

caprylic acid has a higher boiling point / is less volatile ✓

[2 max]

(b)

$[H^+(aq)] = K_w / [OH^-(aq)]$ ✓ = $1.00 \times 10^{-14}/0.500$ = 2.00×10^{-14} mol dm^{-3} ✓

pH = $-\log[H^+(aq)]$ = $-\log 2 \times 10^{-14}$ = 13.699 / 13.7 ✓ *(calculator value: 13.69897)*

[3]

moles **NaOH** in 25.00 cm^3 = moles NaOH = 0.0125 mol ✓

moles **A** in 21.40 cm^3 = moles NaOH = 0.0125 mol ✓

moles **A** in 250 cm^3 = 0.0125 x 250/21.40 = 0.146 mol / [A] = 0.584 mol dm^{-3} ✓

0.146 mol **A** has a mass of 10.8 g

molar mass of **A** = 10.8/0.146 = 74 g mol^{-1} ✓

Therefore **A** is propanoic acid / CH_3CH_2COOH ✓

[5]

[Total: 14]