Question			Expected answers	Marks
3	(a)		$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ (1); (Iron is a transition element since this ion has an) incomplete set of 3d electrons / aw (1)	2
	(b)		Iron in the Haber process / Iron to catalyse reaction of nitrogen and hydrogen / iron in the synthesis of ammonia (1)	1
	(c)	(i)	Calculation of moles / mole ratio (1) Na = 1.21, Fe = 0.603 and O = 2.41; Divide by smallest to give correct molar ratio (1) **OR** Calculation of relative formula mass (1); Working out to get the same percentage compositions (1)	2
		(ii)	+6 (1)	1
	(d)	(i)	$2I^- \rightarrow I_2 + 2e^-$ (1)	1
		(ii)	$FeO_4^{2-} + 8H^+ + 4I^- \rightarrow Fe^{2+} + 4H_2O + 2I_2$ Correct reactants and products (1); Balancing (1)	2
		(iii)	Colour after is orange / yellow / brown (solution) (1)	1
				Total = 10

Question	Expected answers	Marks
4	**Any eleven from** **Bonding and shape** Dative / coordinate bonding – this must be stated in words (1); Water is an electron pair donor / ligand is an electron pair donor / lone pair on oxygen (1); Metal ion accepts electron pair (1); Octahedral / drawing of octahedral complex (1) **Water** In both cases central oxygen is surrounded by four electron pairs (1); In gaseous water (2 bond pairs and) 2 lone-pairs (1); In gaseous water lone pair-lone pair repulsion is greater than other electron pair repulsions (1); Bond angle is 104° – 105° (1); In complex one dative bond is more like a bond pair / water has only one lone pair (1); So less repulsion from the lone pairs (1); bond angle in complex is 106° – 108° / bond angle is slightly bigger than 104° (1) **Distinguishing** Reagent (1) e.g. aqueous sodium hydroxide / add aqueous ammonium thiocyanate / aqueous ammonia; Result of test with Fe^{2+} (1) e.g. green ppt with Fe^{2+} and NH_3 or NaOH and no reaction with SCN^-; Result with Fe^{3+} (1) e.g. orange ppt with Fe^{3+} and NH_3 or NaOH and blood red with SCN-; Suitable equations (2) e.g. $Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$ or $[Fe(H_2O)_6]^{3+} + SCN^- \rightarrow [Fe(SCN)(H_2O)_5]^{2+} + H_2O$ **And** QWC – award one mark for answers using the correct scientific terminology (1)	12
		Total = 12

1. (a)(i) voltage/PD (1)

of a cell when the electrode is **connected** to a reference electrode/ hydrogen electrode (1)

under standard conditions/one of standard conditions specified (1) [3]

(ii) argument based on iron being the more negative system/ based on iron releasing electrons/ argument based on dichromate(VI) being more positive/ based on dichromate(VI) accepting electrons [1]

(iii) $14H^+ + 6Fe^{2+} + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$

species on correct sides (1)

balancing (1) [2]

(b) green/yellow (1)

red and blue absorbed (1) [2]

(c) orbitals split 2 and 3 (1)

2 above 3 (1) [2]

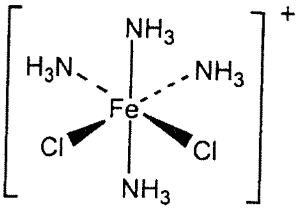
[Total: 10]

2. (a)		zinc (1)	[1]
(b)	(i)	4.46×10^{-3} (mol)	[1]
	(ii)	2.23×10^{-3} (mol)	[1]
	(iii)	4.46×10^{-3} (mol)	[1]
	(iv)	0.283 g (1)	
		56.6% (1)	[2]
(c)	(i)	from brown/yellow (1)	
		to colourless/white (1)	[2]
	(ii)	change blue to colourless more distinct	[1]
(d)		any eg bronze/cupronickel (1)	
		relevant use eg statues/coins/medals (1)	[2]
			[Total: 11]

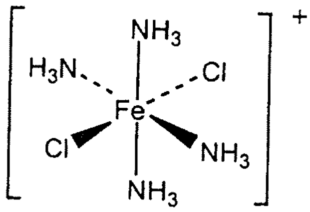
3. (a)(i) $[Fe(NH_3)_4Cl_2]^+$ [1]

(ii) octahedral shape – clearly 3D(1)

cis and trans forms drawn (1)



cis with $2Cl^-$ at 90°



trans with $2Cl^-$ at 180°

labelling (1) [3]

(iii) 6 [1]

(b) anti cancer drug (1)

destroys cell DNA (1) [2]

[Total: 7]

5. most common oxidation states are +2 and +3 (1)

+2 is more stable than +3 (1)

stable aqueous ion is $[Co(H_2O)_6]^{2+}$ (1)

this complex is pink (1)

$[CoCl_4]^{2-}$ (1)

this complex is blue (1)

+3 oxidation stabilised by complexing with ammonia (1)

$[Co(NH_3)_6]^{3+}$ (1)

QWC [1]

[8] Max [6]

plus QWC [1]

[Total: [7]

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

[2]

(ii) $K_c = \dfrac{(2.6 \times 10^{-5})}{(3.1 \times 10^{-3})\,(2.4 \times 10^{-2})^2}$ ✓ = 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^+: $-3 \longrightarrow +1$ / increases by 4 ✓

nitrogen in NO_3^-: $+5 \longrightarrow +1$ / 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 $\longrightarrow$ 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)

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

[1]

(ii)

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

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

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