Unit 5: General Principles of Chemistry II

Section A

Question Number	Question	
1	In a standard hydrogen electrode A the hydrogen gas is at one atmosphere pressure B a solution of 1 mol dm^{-3} sulfuric acid is used C A temperature of 273 K is maintained D a piece of shiny platinum foil is used	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
2	For a redox reaction to be thermodynamically feasible, E_{cell} must be A positive B negative C greater than + 0.3 V D more negative than - 0.3V	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
3	The standard electrode potential for the electrode system based on the equation below is +1.51 V. $MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$ Which of the following statements about the electrode system is correct? A the electrode potential at pH 5 is +1.51 V. B $Mn^{2+}(aq)$ is acting as an oxidising agent. C changing the concentration of $Mn^{2+}(aq)$ would cause a change in the electrode potential. D the electrode used in this half cell is made of manganese.	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
4	Which of the following is always proportional to E_{cell} for a chemical reaction? A ΔH_r B ΔS_{system} C $\Delta S_{surroundings}$ D ΔS_{total}	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
5 (a)	What are the oxidation numbers of carbon in methanol and methanoic acid? Methanol Methanoic acid A -1 +1 B -2 +2 C +1 -1 D +2 -2	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
5 (b)	How many moles of methanol react with one mole of dichromate (VI) ion $Cr_2O_7^{2-}$? A 1 B $^3/_4$ C $1^1/_2$ D 3	
	Correct Answer	Mark
	C 1½	**1**

Question Number	Question	
6	Which of the following will NOT act as a ligand in the formation of complexes? A $C_6H_5NH_2$ B CH_3NH_2 C NH_4^+ D NH_3	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
7	Which of the following ground state electron configurations corresponds to an element most likely to form an oxide with catalytic properties? A $1s^2\ 2s^2$ B $1s^2\ 2s^2\ 2p^6\ 3s^2$ C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
8	X, Y, and Z are three different compounds from the list below. X and Y react together to form an ester. X and Z also react to give the same ester as X and Y, but less readily. Compound Y could be A propanoyl chloride B propanoic acid C propan-1-ol D propanal	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
9	Which of the following isomers of $C_4H_{10}O$ has a chiral centre? A Butan-1-ol B Butan-2-ol C 2-methylpropan-1-ol D 2-methylpropan-2-ol	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
10	When the colourless liquid chlorobenzene is shaken with bromine water, the chlorobenzene becomes a yellow orange colour. What is the interpretation of this? A an addition compound of chlorobenzene and bromine has formed. B the chlorine atom has been replaced by a bromine atom. C a hydrogen atom has been replaced by a bromine atom. D the bromine is more soluble in chlorobenzene than in water.	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
11	What class of organic compound has a characteristic smell and gives a solution in water with a pH of about 10? A Arene B Amine C Aldehyde D Carboxylic acid	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
12	Which chemical term best describes what happens when butylamine is added to a solution of a cobalt(II) salt? A precipitation B redox C proton transfer D complex formation	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
13	The substance of formula $(OCH_2CH_2OOCC_6H_4COOCH_2CH_2OOCC_6H_4CO)_n$ is a A polyester B natural oil or fat C detergent D protein	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
14	The optical isomers of alanine, $CH_3CH(COOH)NH_2$ A have different melting points B rotate the plane of plane polarised light in opposite directions C react at different rates with ethanoyl chloride, CH_3COCl D both occur naturally in protein molecules	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
15	The rate equation for the reaction between aqueous sodium hydroxide and 2-chloro-2-methylpropane is Rate = k[2-chloro-2-methylpropane] The first step in the mechanism of this substitution reaction is A nucleophilic attack by OH^- ions on the carbon atom in the C-Cl bond B electrophilic attack by OH^- ions on the carbon atom in the C-Cl bond C the breaking of the C-Cl bond to form a carbocation D the simultaneous making of a O-C bond as the C-Cl bond breaks	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
16	When hydrogen cyanide, HCN, is added to ethanal, CH_3CHO, the resulting solution has no effect on the plane of polarisation of plane polarised light. This is because A ethanal is not chiral B the product is not chiral C the intermediate is planar D the product is a racemic mixture	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
17 (a)	Benzene, C_6H_6 and cyclohexane, C_6H_{12} A B C D	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
17 (b)	Hydrogen cyanide, HCN, and carbon dioxide, CO_2 A B C D	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
18 (a)	be a solid at room temperature A B C D	
	Correct Answer	Mark
	B Glycine, NH_2CH_2COOH	**1**

Question Number	Question	
18 (b)	give a salt by reaction with sodium hydroxide A B C D	
	Correct Answer	Mark
	B Glycine, NH_2CH_2COOH	**1**

Question Number	Question	
18 (c)	give a sulfonic acid by reaction with fuming sulfuric acid A B C D	
	Correct Answer	Mark
	A Benzene, C_6H_6	**1**

Question Number	Question	
18 (d)	form a precipitate when reacted with 2,4-dinitrophenylhydrazine A B C D	
	Correct Answer	Mark
	D Propanone, CH_3COCH_3	**1**

Question Number	Question	
19 (a)	adjacent polymer chains in $(-CH_2- CH_2-)_n$ A Dative covalent B London forces C Ion-dipole D Ionic	
	Correct Answer	Mark
	B London forces	**1**

Question Number	Question	
19 (b)	copper ions and ammonia in $Cu(NH_3)_4^{2+}$ A dative covalent B London forces C ion-dipole D ionic	
	Correct Answer	Mark
	A Dative covalent	**1**

Section B

Question Number	Question	
20 (a)	Why is the acid necessary ?	
	Correct Answer	Mark
	MnO_4^- needs acid to be reduced to Mn^{2+}	**1**

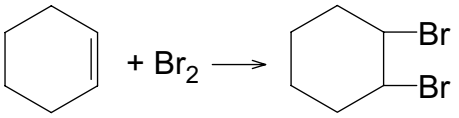
Question Number	Question	
20 (b)	How many moles of Fe^{2+} react with one mole of MnO_4^- ?	
	Correct Answer	Mark
	5	**1**

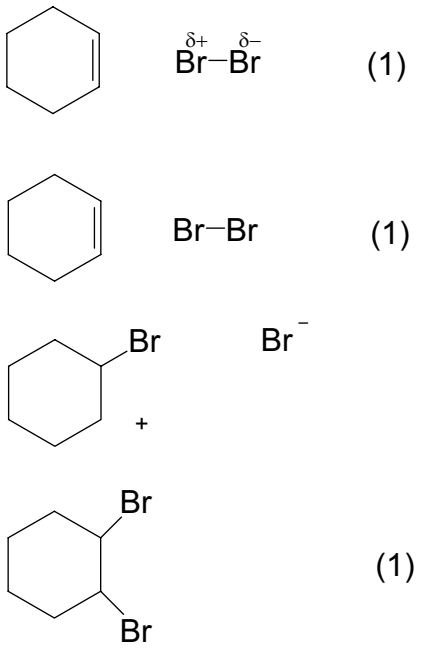
Question Number	Question		
20 (c)(i)	How many moles of Fe2+ are in one tablet is:		
	Acceptable Answers	Reject	Mark
	1.79×10^{-4}		1

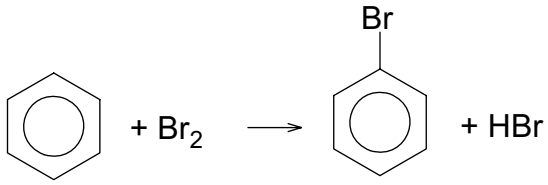
Question Number	Question		
20 (c)(ii)	Use your answer to (i) to calculate the volume of 0.010 mol dm-3 potassium manganate(VII) solution that would be needed to react with one tablet.		
	Acceptable Answers	Reject	Mark
	$1.79x10^{-4}$ mols of Fe^{2+} in one tablet $\therefore$ mols of MnO_4^- = $\frac{1}{5} x 1.79x10^{-4}$ (1) 0.01 mol in 1000 cm^3 $\therefore \frac{1}{5} x 1.79x10^{-4}$ in $\frac{1000}{0.01} x \frac{1.79x10^{-4}}{5}$ = 3.58 = 3.6 cm^3 (1)		1

Question Number	Question		
20 (c)(iii)	Is this a suitable volume to verify the integrity of the firm's claim? How would you alter the experiment to obtain a more suitable volume?		
	Acceptable Answers	Reject	Mark
	No, titration value too low Either: use more tablets Or: use more dilute solution of $KMnO_4$		**1**

Question Number	Question		
20 (d) QWC (i) & (iii)	The recommended consumption of Fe^{3+} per day is 14 mg. The tolerable upper level of consumption of Fe^{2+} per day is 45 mg. The "10 mg iron tablets" produced by a pharmaceutical company contain between 9 and 11 mg of Fe^{2+}. Discuss whether or not this range of iron content is acceptable.		
	Acceptable answers	Reject	Mark
	(It is acceptable because) well below the maximum safe limit (1) Not significantly different from recommended daily dose OR Variation in body mass means that different doses are acceptable OR only if max 1 tablet per day is written on the bottle (1)		**2**

Question Number	Question	
21 (a) (i)	Write the equation for the reaction between cyclohexene,  , and bromine.	
	Correct Answer	Mark
		**1**

Question Number	Question	
21 (a) (ii)	Draw out the mechanism for this reaction.	
	Correct Answer	Mark
		**3**

Question Number	Question		
21 (b) (i)	Write the equation for the reaction between benzene,  , and bromine in the presence of a catalyst of anhydrous iron(III), FeBr3.		
	Acceptable Answers	Reject	Mark
			**1**

Question Number	Question		
21 (b) (ii)	Draw out the mechanism for this reaction. Include an equation for the formation of the species that attacks the benzene ring.		
	Acceptable Answers	Reject	Mark
	$Br_2 + FeBr_3 \rightarrow Br^+ + FeBr_4^-$ / δ+ δ- Br—$FeBr_4$ (1) <u>Step 1</u> Arrow from ring towards Br^+ (1) Intermediate (1) <u>Step 2</u> Arrow from bond, ring to H, to inside ring (and from $FeBr_4^-$ to H^+) and formation of products (1)		**4**

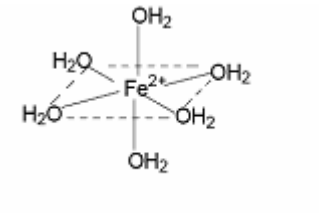
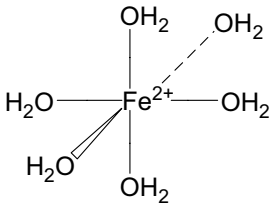
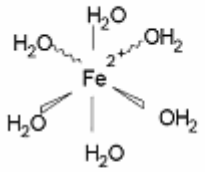
Question Number	Question		
21 (b) (iii)	Write an equation to show how the catalyst is regenerated		
	Acceptable Answers	Reject	Mark
	$FeBr_4^- + H^+ \rightarrow FeBr_3 + HBr$		**1**

Question Number	Question		
21 (c) (i) QWC (i) & (iii)	Comment critically on the differences and similarities of the first steps involving the organic compounds in both reactions.		
	Acceptable Answers	Reject	Mark
	Both attacked by an electrophile (1) Due to stability of delocalised ring (1) benzene attacked by (stronger electrophilic) Br^+ rather than $Br^{\delta+}$ in Br_2 (1)		**3**

Question Number	Question		
21 (c) (ii) QWC (i) & (iii)	Comment critically on why the two intermediates formed in these first steps then react differently?		
	Acceptable Answers	Reject	Mark
	<u>Cyclohexene</u> Addition of Br^- does not involve bond breaking /results in more exothermic reaction than loss of H^+ (1) <u>Benzene</u> No Br^- available in benzene reaction (1) Stability of ring regained by loss of H^+ (1)		**3**

Question Number	Question		
21 (d)	State the number of peaks in the proton nmr spectrum of the product of the reaction between cyclohexene and bromine.		
	Acceptable Answers	Reject	Mark
	Three / 3		**1**

Question Number	Question		
22 (a) (i)	Give the electron configuration of: Fe [Ar] Fe^{2+} [Ar]		
	Acceptable Answers	Reject	Mark
	Fe[Ar] $3d^6 4s^2$ in either order, allowing superscripts to be subscripts Fe[Ar] $3d^6$ or $3d^6 4s^0$ in either order, allowing superscripts to be subscripts Letter d must be lower case	Any other letters	**1**

Question Number	Question		
22 (a) (ii)	Draw the structure of the hexaaquairon(II) ion, $[Fe(H_2O)_6]^{2+}$ clearly showing its shape.		
	Acceptable Answers	Reject	Mark
	 OR  *OR*  *Instead of dotted line* *ALLOW bond to H of H_2O (except on left side if OH_2 is given)* *IGNORE charge unless incorrect*		**1**

Question Number	Question		
22 (a) (iii)	Give the equation for the complete reaction of sodium hydroxide ions with a solution of hexaaquairon(II) ions.		
	Acceptable Answers	Reject	Mark
	$[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow [Fe(OH)_2(H_2O)_4] + 2H_2O$ OR $[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow Fe(OH)_2 + 6H_2O$		**1**

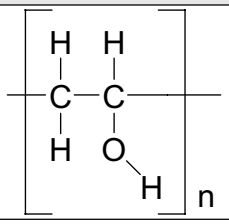
Question Number	Question		
22 (a) (iv)	State what you would SEE if the product mixture in (iii) is left to stand in air.		
	Acceptable Answers	Reject	Mark
	Green precipitate/solid → Foxy-red/red-brown/brown/orange Both colours **and** precipitate/solid needed	Just "Darkens"	**1**

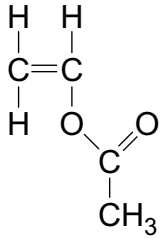
Question Number	Question		
22 (b) (i) QWC (i) & (iii)	Define the term STANDARD ELECTRODE POTENTIAL with reference to this electrode.		
	Acceptable Answers	Reject	Mark
	Emf of cell/ potential difference of cell containing Fe (1) dipping into a 1 mol dm^{-3} Fe^{2+} solution (1) And standard hydrogen electrode/half cell OR hydrogen electrode and 1 mol dm^{-3} H^+ and 1 atm H_2 OR description of standard hydrogen electrode (1) IGNORE temperature	 'SHE'	**3**

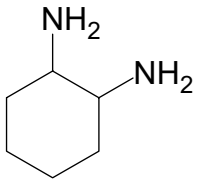
Question Number	Question		
22 (b) (ii) QWC (i) & (iii)	Explain why the value of $E^{\ominus}$ suggests that the iron will react with an aqueous solution of an acid to give Fe^{2+} ions and hydrogen gas.		
	Acceptable Answers	Reject	Mark
	Emf of hydrogen electrode is zero – *stated or implied* e.g. if calclulate E_{cell} = +0.44 V (1) Potential for the reaction is positive so reaction is feasible OR Fe half cell has more negative electrode potential OR H^+ and $(\frac{1}{2})H_2$ has a more positive electrode potential (1)		**2**

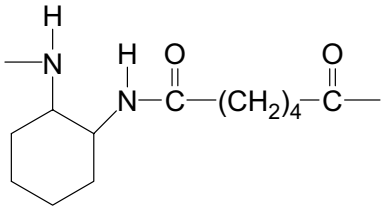
Question Number	Question		
22 (b) (iii)	State why $E^{\ominus}$ values cannot predict that a reaction will occur, only that it is possible.		
	Acceptable Answers	Reject	Mark
	High E_a so slow reaction / reactants are kinetically stable *IGNORE any mention of non-standard conditions*		1

Question Number	Question		
23 (a) QWC (i) & (iii)	Explain why poly(ethenol) is soluble in water.		
	Acceptable Answers	Reject	Mark
	Many –OH groups (1) which can hydrogen bond to water (1)		2

Question Number	Question		
23 (b) (i)	Draw the repeat unit of poly(ethenol)		
	Acceptable Answers	Reject	Mark
			2

Question Number	Question		
23 (b) (ii)	Write the formula of the monomer which polymerises to form poly(vinyl acetate), PVA.(poly(ethenylethanoate))		
	Acceptable Answers	Reject	Mark
			**3**

Question Number	Question		
23 (c) (i)	1,2-dibromocyclohexane reacts with ammonia to produce compound A, $C_6H_{14}N_2$. Give the structural formula of A.		
	Acceptable Answers	Reject	Mark
	 or displayed	$H_2NC_4H_6NH_2$	**1**

Question Number	Question		
23 (c)(ii)	Compound A reacts with hexanedioyl dichloride to produce a polymer. Draw the structure of the repeating unit of this polymer.		
	Acceptable Answers	Reject	Mark
	 link(1) rest of formula (1)	$—OC(CH_2)_4CONHC_6H_4NH—$ Amide link as CONH	**2**

Question Number	Question		
23 (c) (iii) QWC (i) & (iii)	Suggest why this polymer cannot be made into strong fibres.		
	Acceptable Answers	Reject	Mark
	Polymers do not form in an "unkinked" chain OR chain has bends at ring OR chain not linear OR strong fibres require straight chain (1) This polymer has fewer hydrogen bonds between chains (1)		**2**

Question Number	Question		
23 (d)	Classify the two polymerisation reactions.		
	Acceptable Answers	Reject	Mark
	Ethenol: Addition Fibre: Condensation		**1**

Section C

Question Number	Question		
24. (a) (i)	Define what is meant by a TRANSITION ELEMENT.		
	Acceptable Answers	Reject	Mark
	An element which forms ions in at least one of its compounds which have a partly filled shell of d electrons (1)		**1**

Question Number	Question		
24 (a) (ii) QWC (i) & (iii)	Explain the processes which lead to hydrated transition metal ions being coloured.		
	Acceptable Answers	Reject	Mark
	The water ligands split the d orbitals into one set at lower and one at higher energy (1) Light is absorbed (1) and the electron promoted to a higher level (1) The correct sequence must be given to score either of the last two marks	Any mention of light emitted scores zero	**3**

Question Number	Question		
24 (b) (i)	Give the formula of the red copper oxide which causes the red colour in glass.		
	Acceptable Answers	Reject	Mark
	Red Cu_2O (1)		**1**

Question Number	Question		
24 (b) (ii)	The production of red copper oxide is involved in a test for a functional group in organic chemistry. Name the reagent used in this test and the functional group it detects.		
	Acceptable Answers	Reject	Mark
	Benedicts/Fehlings (solution) (1) Accept recognisable phonetic spelling eg Felings, Benedicks, Benedikts Aldehyde (1)	Failings	**2**

Question Number	Question		
24 (c) QWC (i) & (iii)	Why would the addition of iron(II) oxide, FeO, or osmium(III) oxide, Os_2O_3, not replace aluminium ions in alumina?		
	Acceptable Answers	Reject	Mark
	FeO is 2+ not 3+ (1) Os^{3+} has too large a radius (1)		**2**

Question Number	Question		
24(d)(i) QWC (i-iii)	Starting with a chromium(III) compound, state how it could be converted into a chromium(VI) compound, a chromium(II) compound and a complex ion. You should include equations and colour changes in your answer.		
	Acceptable Answers	Reject	Mark
			7

	reagent	colour change	equation	
(III)→(VI)	(1)	Green→orange-yellow (1)	(1)	
(III)→(II)	(1)	Green→blue (1)	$Zn+2Cr^{3+}\rightarrow Zu^{2+}+2Cr^{2+}$ (1)	
(III)→complex	(1)	(1)	(1)	

<u>Reagent</u>

$E^{\ominus}$ for reagent must be more positive than 1.6 V

$E^{\ominus}$ for reagent must be more negative than -0.7 V. Do not allow a reducing agent that reacts with water.

<u>Colour change</u>
Do not penalise lack of green twice.

<u>Complex formation</u>
e.g. formation of $[Cr(NH_3)_6]^{3+}$
$[Cr(OH)_6]^{3-}$
$[Cr(en)_3]^{3+}$
$[Cr(edta)]^{-}$
$[Cr_2(Cu_3CO_2)_4\,(H_20)_2]$
$[Cr(CH_3CO_2)_4]$

Reagent and colour change must fit the complex

Score up to 7 marks (from the 9 marking points)

Question Number	Question		
24 (d) (ii) QWC (i-iii)	Discuss the chemistry of the use of chromium salts in breathalysers. Explain why they are no longer used and describe the chemistry of one modern type of breathalyser.		
	Acceptable Answers	Reject	Mark
	Breathalyser • Original contained dichromate/chromate ions which were reduced to green (chromium(III) by ethanol in breath (1) • Extent going green judgemental / chromium(VI) compounds carcinogenic (1) Then **Either** New one consists of a fuel cell (1) where ethanol oxidised by air (using a platinum catalyst) / Quantity of electricity proportional to amount of ethanol in breath (1) **Or** New one consists of an IR spectrometer (1) which measures line in fingerprint region / Amount of IR absorbed depends on amount of ethanol in breath (1)		**4**