ARC

CHEMISTRY TRIAL 2002
MARKING GUIDELINES

The Core
Multiple choice (1 mark each)

1D 2D 3C 4B 5B 6D 7A 8C 9B 10C 11D 12A 13A 14D 15C

Extended answers

Q	Answer	Mark
16a	**X** is $^{222}_{86}Rn$ **Y** is $^{218}_{85}At$	**2**
16b	e.g. In order to determine whether the oxygen, that was involved in the formation of water during an esterification reaction, came from the acid or from the alcohol, scientists used the radioactive oxygen-19 isotope when they prepared the alcohol, "labelled" the oxygen in the alcohol preparing the alcohol	**1** **1**
17a	chloroethene	**1**
17b	unsaturation (i.e. double and/or triple carbon-carbon bonds)	**1**
17c i		**1**
17b ii	initiation - an H atom (radical) bonds with a C of vinyl chloride, causing the carbon to have a valency of 5, a highly unstable state propagation (a chain reaction) – the double bond opens and the molecule becomes a radical which bonds with another vinyl chloride making it have an unstable structure termination – two radicals join to form a stable molecule	**1** **1** **1**
18a	The joining of small organic molecules to form a large molecule, with the splitting out of small inorganic molecules (usually water).	**1**
18b	Every second monomer (glucose) unit is upside down.	**1**
19	advantages: higher flash point renewable no SO_2 residue disadvantages: higher cost less energy per litre than petrol lower ignition temperature *(2 of each)*	**2** **2**

20a	a source of electricity (e.g. a battery)	**1**
20b	$Al_{(s)} \rightarrow Al^{3+} + 3e^-$ +1.68 V $Cr^{3+} + 3e^- \rightarrow Cr_{(s)}$ – 0.74 V $Al_{(s)} + Cr^{3+} \rightarrow Al^{3+} + Cr_{(s)}$ 0.94 V	**1** **1**
21	eg testing acidity/alkalinity of *(any 2)* * soils (many plants are very pH specific) * home swimming pools * fish tanks * waterways (indication of chemical or biological pollution)	**2**
22a	Solubility decreases. According to Le Chatelier, increasing the temperature (an input of heat) shifts the equilibrium position towards the products (gaseous CO_2) to remove some of the added heat.	½ **1**
22b	Solubility decreases. Opening the lid results in a drop in the concentration of gaseous CO_2 (but does not affect the concentration of aqueous CO_2). Equilibrium position shifts towards the reactants to replace some of the lost $CO_{2(g)}$.	½ **1**
23	$n_{Al} = m/MM = 5.4/27 = 0.2$ mol $n_{H2} = 3/2\ nAl = 0.3$ mol $V_{H2} = n \times Vmol = 0.3 \times 24.45 = 7.335$ L	**1** **1** **1**
24a	HCl is a strong acid, it is completely ionised in water. So the concentration of H^+ ions = 0.2 mol L^{-1}. Citric acid is a weak acid, so it is not completely ionised. So the concentration of H^+ ions << 0.2 mol L^{-1}. A lower $[H^+]$ means a higher pH.	**1** **1** **1** **1** **1**
24b	$pH = -\log 0.2 = 0.70$	**1**
24c	Cl^-	**1**
25a	$CH_3CH_2CH_2OH + CH_3COOH \rightarrow CH_3COOCH_2CH_2CH_3 + H_2O$	**1**
25b	To allow the reaction at an elevated temperature (in order to increase rate), without the loss of any of the reactants or the products.	**1**

22

26	NO_2, has its origins in car engines (*2 sources*) $SO_{2(g)}$ is obtained from the burning of fossil fuels or from the smelting of sulfide ores	1
	e.g. $ZnS_{(s)} + 1½\ O_{2(g)} \rightarrow ZnO_{(s)} + SO_{2(g)}$ (*an equation*)	1
	These acidic oxides can dissolve in water droplets in clouds or in rain to produce dilute acids (*formation of acid*)	1
	e.g. $SO_{2(g)} + H_2O_{(l)} \rightarrow H_2SO_3(aq)$ (*an equation*)	1
	Acid rain can affect plants and animals which can live only in a narrow pH range environment, weather rocks, stone buildings, marble structures, and corrode metal structures. (*2 effects*)	2
	e.g. $2H^+_{(aq)} + CaCO_{3(s)} \rightarrow Ca^{2+}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$ or $2H^+_{(aq)} + Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + H_{2(g)}$ (*an equation*)	1
27a	Advantage: Increased temperature increases the rate of any reaction, so it will shorten the time needed to get some product in this very slow reaction.	1
	Disadvantage: The position of the equilibrium depends on temperature. This process is an exothermic reaction, so higher temperature favours the reactants resulting in a low yield at equilibrium.	1
27b	high pressure catalyst (Fe_3O_4 or Cu) removal of ammonia from the reaction mixture	1 1 1
28	Total hardness = [$CaCO_3$} in ppm	1
	The sample of water is made basic (pH 10) by ammonia.	1
	It is then titrated with EDTA using eriochrome black-T indicator The indicator changes from red to blue at the end point.	1 1 1
	The result (volume of EDTA of known concentration) is converted to mg of $CaCO_3\ L^{-1}$ (i.e. ppm), given that $n_{CaCO3} = n_{EDTA}$	1
29a	Lead is a cumulative poison, becoming more concentrated along the food chain.	1
	Lead affects the human nervous system, which can cause diminished mental ability, paralysis and death.	1
	Phosphate is a nutrient for many organisms. High concentration in waterways can cause surface algal bloom	1
	which cuts down the oxygen and the sunlight essential for the survival of the organisms deeper in the water.	1

29b	The test for lead ions in water is adding the (concentrated) water sample to sodium iodide solution.	1
	A yellow precipitate indicates the presence of lead ions.	1
	The test for phosphate ions (in high enough concentration) is adding the (concentrated) water ample to sodium molybdate, followed by ascorbic acid (vitamin C).	1
	An intense blue colour indicates the presence of phosphate ions.	1

Question 30 - INDUSTRIAL CHEMISTRY

a i	$N_2O_4 \rightleftarrows 2NO_2$	1
a ii	endothermic	½
	Increased K means more products and less reactants, so the equilibrium has sifted towards the products. This happens if heat is a reactant; to use up some of the extra heat there is a shift towards the products.	1
a iii	Nothing. (Only a change in temperature can affect the value of K.)	½
a iv	initial $[N_2O_4] = 0.2/20 = 0.01$ mol L^{-1}	1
	n_{N2O4} used = ½n_{NO2} produced. = ½ x (0.010 – 0.005) x 20 = 0.05 mol n_{N2O4} at equilibrium = 0.2 – 0.05 = 0.15 mol $[N_2O_4]$ at equilibrium = 0.15/20 = 0.0075 mol L^{-1}	1
b	step 1. SO_2 is obtained either as a by-product of sulfide ore smelting, or from the combustion of sulfur.	1
	Condition: molten dry sulfur sprayed into (hot) furnace.	1
	step 2. SO_2 is converted to SO_3 by reaction with oxygen from air.	1
	Conditions: slightly elevated pressure, slightly oxygen enriched air, moderate temperatures (between 550°C and 400°C)	1
	and using V_2O_5 as catalyst	1
	step 3. SO_3 is converted to H_2SO_4.	1
	Conditions: Dissolve SO_3 in concentrated H_2SO_4 to get oleum ($H_2S_2O_7$)	1
	Add water to get H_2SO_4 (twice as much as was used to get oleum).	1
c i	In tank X: silvery liquid forming at the cathode bubbles at the anode	½ ½
	In tank Y: bubbles at both electrodes but at a faster rate at the cathode than at the anode.	½ ½
c ii	– {–0.83 + (–0.40)} = 1.23 V	1

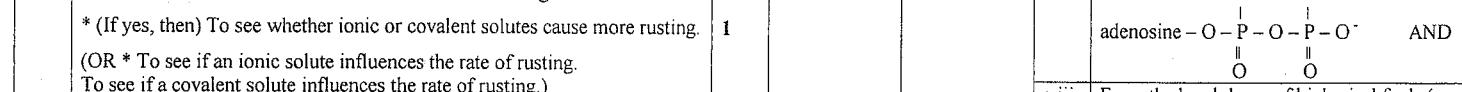
c iii	larger	1
d i	$CH_3(CH_2)_{16}COONa$	1
d ii	Skimmed the solid off the ice cold, salt saturated product mixture.	½
	Shook some of the solid with water in a test tube to see if a lather developed, which would indicate soap.	½
d iii	Soap has a non-polar "tail",	1
	which mixes with non-polar substances e.g. grease, but is do not mix with water.	1
	Soap has an ionic (anionic) head, which is soluble in water.	1
	The soap anions form a layer with heads in, tails out of the water.	1
	This lowers the surface tension of water, making it easier to mix with other substances.	1
	The grease globules formed (with soap tails in grease, head in water) are prevented from joining with each other by the repulsion between the anionic heads on the surface of the globules. Thus the globules can be flushed away.	1

Question 31 - SHIPWRECKS AND SALVAGE

a	Leaching of minerals from the soil and rocks	1
	Minerals from under the crust being added at vents in mid-ocean ridges.	1
b i	Both water and air are needed for rusting.	1
b ii	In tube 4	1
	Zinc, being more reactive than iron, offers it cathodic protection.	1
	Copper, being less reactive than iron, does not offer it cathodic protection.	1
b iii	* To see if dissolved matter influences the rate of rusting.	1
	* (If yes, then) To see whether ionic or covalent solutes cause more rusting.	1
	(OR * To see if an ionic solute influences the rate of rusting. To see if a covalent solute influences the rate of rusting.)	
c i	The rate of any reaction decreases with decreasing temperature, because fewer reactant particles have the activation energy needed to overcome the energy barrier (energy of the activated complex).	1
c ii	In the equilibrium $O_{2(g)} \rightleftarrows O_{2(aq)}$, high pressure favours the side with the fewer gas molecules, i.e. $O_{2(aq)}$	1
c iii	Aerobic organisms in the water use oxygen for respiration	1

c iv.	The waste of some (anaerobic) bacteria	1
	cause the water around them to become slightly acidic.	1
	The H^+ ions react with iron ($Fe_{(s)} + 2H^+_{(aq)} \rightarrow Fe^{2+}_{(aq)} + H_{2(g)}$)	1
	(The Fe^{2+} ions can then react with water to produce more H^+ $Fe^{2+}_{(aq)} + 2H_2O_{(l)} \rightarrow Fe(OH)_{2(s)} + 2H^+_{(aq)}$)	
d i	To wash our the salt water that soaked into the wood.	1
	Without this procedure the wood would have cracked	1
	because as the water slowly evaporates from the wood, the dissolved salts crystallised out.	1
	As the crystals grow they crack the wood.	1
d ii	e.g. tarnished silver (silver sulfide)	1
	$Ag_2S_{(s)} + H_2O_{(l)} + 2e^- \rightarrow 2Ag_{(s)} + HS^-_{(aq)} + OH^-_{(aq)}$	1
e i	$n_{H2} = {}^{V}/_{Vmol} = {}^{0.489}/_{24.45} = 0.02$ mol	1
e ii	2 moles of electrons are needed for each mole of hydrogen formed $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ 0.02 moles of H_2 needs 0.04 moles of electrons.	1
e iii	$Al^{3+}_{(aq)} + 3e^- \rightarrow Al_{(s)}$	1
e iv	3 moles of e^- are needed to form 1 mol Al	1
	0.04 mol of e^- forms ${}^{0.04}/_{3}$ mol Al	
	$= {}^{0.04}/_{3} \times 26.98 = 0.36$ g Al = change of mass	1

Question 32: THE BIOCHEMISTRY OF MOVEMENT

a i	mitochondria	1
a ii		2
a iii	From the breakdown of biological fuels (e.g. carbohydrates and fats).	1
a iv	phosphodiester bond	1
b	Both have many –OH functional groups	1
	which make the molecules polar.	1
	These polar molecules are attracted to polar water molecules	1
	by strong hydrogen bonds (or dipole-dipole bonds, as H bonds seem to have disappeared from the syllabus!).	1

c i	$CH_3(CH_2)_nCOOH$	1
c ii	$CH_2OHCHOHCH_2OH$ (or the graphic formula, showing bonds)	1
c iii	acetyl CoA (OR acetate)	1
c iv	They enter the TCA cycle (producing 2 CO_2 molecules each)	1
	followed by the cytochrome chain which produces the majority of ATP	1
d i	1 is hydrophobic force	1
	2 is electrostatic force (ionic attraction)	1
	3 is disulfide bond (sulfur bridge)	1
d ii	The electrostatic force between the $-COO^-$ and the $-NH_3^+$ ionic side chains	1
	Some of the extra H^+ ions would combine with the $-COO^-$ which would lose its charge as it forms –COOH.	1
	This would stop it being attracted to the $-NH_3^+$, the strands of protein would drift apart, altering the tertiary structure of the protein, i.e. the protein would become denatured.	1
e i	(Type 2 cell) – has few mitochondria – has many contractile filaments – has poor blood supply – contracts relatively rapidly – carries out mostly anaerobic respiration *(any 2)*	2
e ii	Lactic acid	1
	formed because the rate of ATP usage by these muscles was greater than the ATP production by the oxidation of glucose (OR oxygen was not supplied fast enough to the muscles to remove hydrogen from the cytochrome chain) resulting in anaerobic respiration.	1
	The lactic acid is exported from the cell and is recycled into glucose in the liver. (It is oxidised back to pyruvic acid when aerobic conditions are reestablished. Pyruvic acid, being a normal product of glycolysis, can then proceed to the TCA cycle.)	1

Question 33 - **THE CHEMISTRY OF ART**

a i	Transition metals (OR d block)	1
a ii	1, 2 or 3 electrons in their valence shells (2 being the most common)	1
	Between 9 and 18 electrons in their second outermost shells. (i.e. except for Zn, Cd and Hg they all have an incomplete d subshell.)	1
a iii	Fe atom $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$	1
	Fe^{3+} ion $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$	1

a iv	Iron loses 2 electrons from its valence shell to form Fe^{2+}.	1
	Of the partially filled subshells a half filled one is most stable. Since the energy level of the 3d subshell is very close to that of the 4s subshell, an electron might jump from 3d to the now empty 4s subshell. ($3d^5$ arrangement is more stable than $3d^6$.)	1
	If this electron also is lost, an Fe^{3+} ion results.	1
a v		1
a vi	sodium OR magnesium OR aluminium	1
b	Each electron spin generates a small magnetic field. Paired electrons with opposite spins cancel each other's electric field. This element has four unpaired electrons, so is quite strongly magnetic.	1
c	3	1
	There is a larger increase between the 3rd and the 4th ionisation energies than expected, indicating that the first 3 electrons were at a greater distance from the nucleus than the rest, i.e. there were only 3 electrons in the outermost shell.	1
d	In reflectance spectroscopy infrared light is directed	½
	at an opaque sample.	½
	Light of some wavelengths are absorbed	½
	the others are reflected.	½
	In absorbance spectroscopy visible white light is directed	½
	through a transparent sample.	½
	Light of some wavelengths are absorbed	½
	the others are transmitted.	½
	In both cases the absorbed light shows up as missing lines in the spectrum.	1
	The wavelengths of these lines are characteristic of the elements in the sample.	1
e i	+7	1
e ii	$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	1