13

Academic

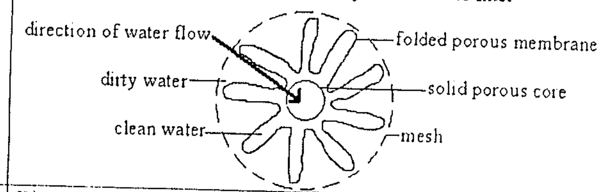
CHEMISTRY TRIAL 2001
MARKING GUIDELINES

The Core
Multiple choice (1 mark each)
1D 2A 3B 4A 5B 6C 7B 8A 9B 10D 11A 12C 13D 14C 15D

Extended answers

Q	Answer	Mark
16	${}^{238}_{92}\boxed{U} + {}^{12}_{\boxed{6}}C \rightarrow {}^{\boxed{246}}_{\boxed{98}}\boxed{Cf} + 4\,{}^{1}_{0}n$ *– ½ for each mistake*	2
17	fluorine-18 – used in positron emission tomography to study brain function, to diagnose epilepsy, heart disease and certain types of cancer phosphorus-32 – treating excess red blood cells cobalt-60 – source of external radiation for cancer treatment technetium-99 – detection of blood vessel constrictions, blood clots, brain tumours iodine-121 – destroying (some of the overactive) thyroid gland iodine-123 – diagnosis of thyroid diseases iridium-192 – internal source of radiotherapy *correct element but incorrect isotope*	2 *1*
18a	*one of* protein, cellulose, starch	1
18b	*biopolymers are biodegradable, polymers from petroleum products are not *petroleum reserves are diminishing	1 1
19a i	$C_6H_{12}O_{6(aq)} \rightarrow 2CO_{2(g)} + 2C_2H_5OH_{(aq)}$ catalyst: yeast *½ for equation, ½ for catalyst*	1
19a ii	$CH_3CH_2OH_{(l)} \rightarrow CH_2{=}CH_{2(g)} + H_2O_{(l)}$ catalyst: concentrated H_2SO_4 *½ for equation, ½ for catalyst*	1
19b	Water dissolves ionic and polar compounds by forming dipole-ion, dipole-dipole or H bonds with the solute particles. The OH end of ethanol can form the same type of bonds.	1 1
19c	Energy from ethanol = n x ΔH = 785/46.1 x 1367 = 23278 kJ Energy from octane = n x ΔH = 698/114.2 x 5470 = 33433 kJ Since more energy from octane, can travel further on octane.	1 1 1
20a	*any copper solution, eg* copper (II) sulfate	1
20b	$Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$	1
20c	oxidation	1
21a	To minimise the decrease in pressure caused by the opening of the bottle, the equilibrium shifts towards the side with the greater number of gas molecules, ie towards the formation of CO_2 gas bubbles.	1

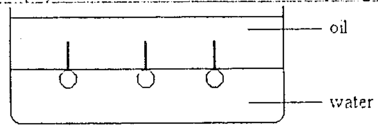
21b	Solubility of gases is greater at lower temperature, ie dissolving is exothermic. So lowering the temperature favours the reaction which produces heat so equilibrium shifts towards $CO_{2(aq)}$, away from the formation of gas bubbles.	1
21c	As $CO_{2(g)}$ is removed each of the equilibrium reactions shifts to the left (towards the reactants). $[H_3O^+]$ decreases, pH increases.	1
22a	Reduction. An electron is gained (or e^- is a reactant) or there is a decrease in the oxidation number of vanadium (from +5 to +4) *If there is no reason or the reason is wrong, no mark at all.*	1
22b	+5	1
23a	$CuS_{(s)} + O_{2(g)} \rightarrow Cu_{(s)} + SO_{2(s)}$	1
23b	n_{CuS} 1000000/95.6 = 10460 mol $n_{SO2} = n_{CuS}$ = 10460 mol V_{SO2} = n x V_{molar} = 10460 x 24.45 = 255753 L (= 2.56 x 10^5 L)	1 1 1
23c	$SO_{2(g)} + H_2O(l) \rightarrow H_2SO_{3(aq)}$	1
23d	$H_2SO_{4(aq)} + CaCO_{3(s)} \rightarrow H_2O_{(l)} + CO_{2(g)} + CaSO_{4(aq)}$	1
24a i	$CH_3CH_2COOCH_2CH_{3(aq)} + H_2O_{(l)}$	1
24a ii	ethyl propanoate	1
24b i	$[OH^-]$ = 0.5 mol L^{-1} $[H+] = 2x10^{-14}$ (or pOH = 0.30) pH = -log $2x10^{-14}$ = 13.7 (or pH = 14 – pOH = 13.7)	1
24b ii	$H_2SO_4 + 2NaOH \rightarrow 2H_2O + Na_2SO_4$ n_{NaOH} = CV = 0.5 x 0.068 = 0.034 mol n_{H2SO4} = ½ n_{NaOH} = 0.017 mol	 1 1
25a i	HCl provides H^+ ions (H_3O^+) in aqueous solutions $HCl + H_2O \rightarrow H_3O^+ + Cl^-$	1 1
25a ii	The ammonium ion of NH_4OH is a proton donor $NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$	1 1
25b	`:F: H :F: H` / `:F:B + :N:H → :F:B:N:H` / `:F: H :F: H` Lewis acid (BF_3)	1 1
26a (cont)	At higher pressure equilibrium favours side with fewer gas molecules, i.e. an increase in NH_3 formation At high temperature equilibrium is reached quickly but with low yield (equilibrium position is towards the reactants).	1 1

26a (cont)	At low temperature equilibrium yield is high, but it takes too long (weeks or months to reach equilibrium. (At moderate temperature get reasonable yield in reasonable time.)	1
26b i	iron (Fe), or magnetite (Fe_3O_4) with its surface reduced to iron atoms	1
26b ii	The alternative pathway offered by the catalyst has a lower activation energy. Therefore the number of molecules at the low temperature which have sufficient energy to overcome this lowered energy barrier can be the same as the number of molecules at the high temperature with sufficient energy to overcome the higher energy barrier.	1 1
27a	$n_{NaOH\ reacted} = n_{NaOH\ originally} - n_{NaOH\ remaining\ to\ be\ neutralised\ by\ HCl}$ = 0.15 x 0.1*(1mark)* – *(1mark)* 0.23 x 0.0231*(1mark)* = 0.0097 mol	3
27b	$n_N = nNH_4^+ = n_{NaOH\ reacted}$ = 0.0097 mol	1
27c	percent of N = n x MM*(1mark)* x 100/m *(1 mark)* = 0.0097 x 14 x 1000/0.95 = 14.3%	2
28a	porous polypropylene, polysulfone or teflon	1
28b	cross section of a microscopic membrane filter 	1
28c	Dirty water under pressure is pushed against the membrane. The pores in the membrane are too small to allow microorganisms and other particulate matter through, but are large enough to allow the passage of water and small ions.	1
29a	The ozone layer in the stratosphere is needed to shield living organisms in the lower atmosphere from harmful ultraviolet radiation.	1
29b	Ozone, being a powerful oxidising agent, can cause harmful chemical changes in the cells of living organisms.	1
30a	concentration of sample = $\frac{\text{absorbance of sample x concentration of standard}}{\text{absorbance of standard}} = \frac{0.078 \times 5.85}{1.087}$ = 0.42 ppm	1
30b i	n_{BaSO_4} = m/MM 0.27/233.34 = 1.157x 10^{-3}	1
30b ii	The number of moles of H_2SO_4 = 2.05 x 0.01 = 0.0205 mol, which would be enough to precipitate 0.0205 moles of $BaSO_4$. The reaction stopped before this, so all the Ba^{2+} must have been used up, i.e. sulfuric acid was in excess.	1
30b iii	$n_{Ba2+} = n_{BaSO_4}$ 0.001157 mol m_{Ba2+} = n x MM = 0.001157 x 137.34 = 0.16 g 100mL^{-1}	1

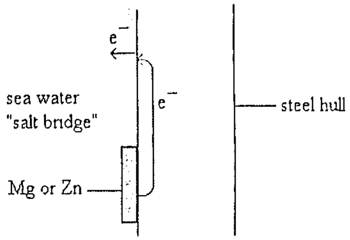
∴ 1.59 g L^{-1}

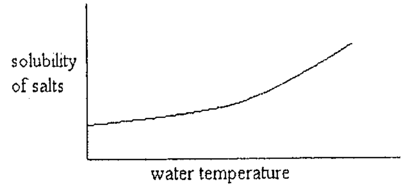
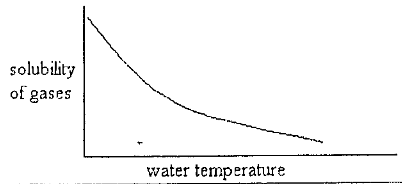
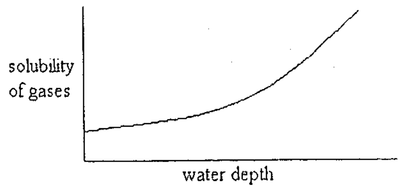
OPTION 1. **INDUSTRIAL CHEMISTRY**

1a	Wool – increasing population and increasing affluence → too much demand – alternative cheaper Rubber – increased number of vehicles → can't keep up with demand – limited supply Soap – increased population → increased demand – starting material (fat) used elsewhere (for food)	1
1b	Wool – acrylic, nylon Rubber – styrene-butadiene Soap – detergents	1
2	C	1
3a	concentration (mol L^{-1}) | $[N_2]$ | $[H_2]$ | $[NH_3]$ initial | 0.19 | 0.38 | 0.23 change | +0.04 | +0.12 | -0.08 at equilibrium | 0.23 | 0.50 | 0.15	1 1
3b	$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$	1
3c	$K = \frac{0.15^2}{0.23 \times 0.5^3} = 0.783$	1
4	is not soluble in water has low melting point has low density	1 1 1
5a i	The energy used to remove an H^+ from an H_2SO_4 molecule is much less than the energy released in forming a new bond between the H^+ and a water molecule.	1 1
5a ii	The heat released when a small volume of acid and water react is insufficient to suddenly vaporise a large volume of (acidified) water, but is sufficient to vaporise a small volume of water. (The boiling point of sulfuric acid is much higher, so it will not vaporise.)	1 1
5b	Wear eye protection, apron and gloves. Have some solid Na_2CO_3 handy to neutralise any spills. (and/or) Perform the dilution near a sink to quickly dilute any spill. Place water and stirring rod into a beaker Slowly pour a small quantity of the acid along the rod to avoid splashing. Stir. If the mixture becomes too hot allow it to cool before adding more acid.	1 1
6	B	1
7	Only the magnesium-lead cell is galvanic. The reaction is spontaneous (exothermic). The released energy can be in the form of electrical energy. (Chemical energy converted to electrical energy → galvanic cell.) In the copper-zinc cell the reaction will not proceed unless there is a constant supply of electrical energy. (Electrical energy converted to electrical energy → electrolytic cell)	1 1

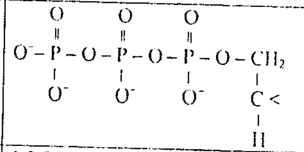
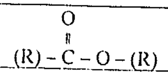
8a	$2Cl_{(aq)} + 2H_2O_{(l)} \rightarrow Cl_{2(g)} + H_{2(g)} + 2OH_{(aq)}$	1
8b	i. mercury contamination of the environment (waterways, lakes, oceans) ii. NaOH produced is contaminated by some NaCl. *(or)* The asbestos from which the diaphragm is made is a health hazard.	1 1
9		1
10a	$\rightarrow NaHCO_{3(s)} + NH_4Cl_{(aq)}$	1
10b	$n_{CO_2} = V/V_{molar} = 1000/24.45 = 40.9$ mol $n_{Na_2CO_3} = nCO_2 = 40.9$ mol $m_{Na_2CO_3} = n \times MM = 40.9 \times 106 = 65.4$ g	1 1

OPTION 2 SHIPWRECKS AND SALVAGE

1a	Galvani	1
1b	Davy	1
1c	Faraday	1
2	The aluminium quickly forms aluminium oxide with air. This oxide layer is strongly bonded to the underlying aluminium, forming a protective layer preventing further oxidation.	1
3a	$0.34 - (-0.13) = 0.47$ V	1
3b	i. at anode: iodine at cathode: copper ii. at anode: oxygen at cathode: hydrogen	1 1
4	Container II	1
5a	 Electrons are lost by both the steel and the sacrificial metal. As the electrons are removed from the steel, they are immediately replaced by electrons from the sacrificial metal.	2 1 1
5b	On metal tanks buried in moist ground.	1

5c i	paint, grease, tin coating, enamelling, passivating the metal (OR) using applied voltage	1
5c ii	A barrier exists between the iron/steel and the oxidising material. (OR) The electron lost from the steel hull is immediately replaced by electrons from the power source.	1
6a	Bacteria that do not need oxygen	1
6b	They are sulfur reducing organisms, converting sulfates to sulfides, which facilitates the oxidation of iron. As well, their wastes reduce the pH of the water, which speeds up corrosion.	1 1
7a		1
7b		1
7c		1
8a	The removal of water causes salt to crystallise out. If the crystals form in the pores of porous objects the objects might crack, become distorted or react chemically with the object.	1
8b	i. $Ag_{(s)} + H_2S_{(aq)} \rightarrow AgS_{(s)} + H_{2(g)}$ ii. $AgS_{(s)} + 2e^- \rightarrow Ag_{(s)} + S^{2-}_{(aq)}$ iii. $CaCO_{3(s)} + 2H^+_{(aq)} \rightarrow Ca^{2+} + CO_{2(g)} + H_2O(l)$	1 1 1

OPTION 3 The Biochemistry of Movement

1a	mitochondria	1
1b	to store energy (which is to be used to drive other metabolic reactions.)	1
1c		1
2a	1,2,3-propanetriol	1
2b i	Up to three H bonds hold each glycerol molecule to its neighbour. These bonds slow down the movement of each glycerol molecule past another molecule. *H bonds – 1 mark*	2
2b ii	The strength of the H bonds between glycerol and water is similar to the strength of the glycerol-glycerol and the water-water H bonds.	1
2c i	The H bonds holding the water molecules to each other are too strong to be broken by the weak dispersion forces on non-polar coconut oil.	1
2c ii		1
2c iii	They are concentrated stores of energy.	1
3a	hydrogen bond	1
3b	The H bond gets broken	1
3c i	$NH_2CHCOOH$ *or* $NH_2CHCOOH$ *or* $NH_2CHCOOH$ *or* NH_2CH_2COOH $(CH2)_4NH_2$ OH CH_2O	1
3c ii	The folds in the protein (enzyme) are such that only a particular (part of a particular) substrate can fit into the folds and bind to the enzyme.	1
4a i	calcium ions	1
4a ii	myocin and actin	1
4a iii	they form temporary bonds	1
4a iv	ATP → ADP + P + energy	1
4a v	Type I cell contracts more slowly has more mitochondria is better supplied with blood has fewer contractile fibres *(any two of these)*	2

4b i	$CH_3CHOHCOOH \rightarrow CH_3CH_2OH + CO_2$	1
4b ii	Similarities: *The two processes give the same product. *Both processes are anaerobic. Differences *One mole of glucose gives twice the number of moles of each product as one mole of lactose. *Lactic acid removal occurs in animal cells, fermentation occurs in yeast cells. *(any 3 points)*	3

OPTION 4. THE CHEMISTRY OF ART

1a	a pigment and a liquid to carry the pigment	1
1b	d block – transition metals	1
2a i	Emission spectrum is produced when excited electrons (which absorbed energy as a result of heating or radiation) give out characteristic quanta of energy as they return to lower energy levels.	1
2a ii	The sample is vaporised (by flame or electricity). The emissions from the sample are (concentrated with a lens and) passed through a prism (which separates the emitted radiation into its different wavelengths).	1 1
2b i	The characteristic lines are at the same wavelength for both spectra.	1
2b ii	Emission spectrum appears as coloured lines on a black background. Absorption spectrum appears as black lines on a background of the visible spectrum of white light.	1
2c i	potassium	½
2c ii	strontium	½
2c iii	sodium	½
2c iv	copper	½
3a i	2.8.16.2	1
3a ii	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$	1
3a iii	1s $\boxed{\uparrow\downarrow}$ 2s $\boxed{\uparrow\downarrow}$ 2p $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$ 3s $\boxed{\uparrow\downarrow}$ 3p $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$ 3d $\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$ 4s $\boxed{\uparrow\downarrow}$	1
3b	the vanadium (II) ion, V^{2+}	1