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HSC Trial Examination 2002

Chemistry

Solutions and marking guidelines

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Section I

Part A

Answer and explanation	Outcomes assessed
Question 1 A Since this is a weak acid, only a small proportion of molecules have ionised. Therefore, the majority of molecules have remained intact.	H2
Question 2 A The greater amount of gas was produced at lower temperature (indicating that it is an exothermic process) and higher pressure.	H7, H8
Question 3 D By adding more water, the solution must now be more dilute. Since the pH has decreased, the solution is also less alkaline.	H10
Question 4 D A. Copper (II) fluoride provides F^- ions and so equilibrium shifts to the left. B. Hydrogen chloride will dissolve in the water increasing the H_3O^+ concentration and so shift equilibrium to the left. C. Sodium hydroxide would provide OH^- ions; these would react with the H_3O^+; the equilibrium would shift to the right in an attempt to replace the H_3O^+. D. Cu^{2+} and NO_3^- ions do not affect any of the species present in this equilibrium.	H2, H8
Question 5 B The esters structure has double bonded oxygen on the single carbon; this C must be from the acid therefore the acid was methanoic acid. The other carbon chain in the ester contains 3 consecutive C atoms therefore this section was originally 1-propanol.	H9
Question 6 D As water flows, it mixes with air from the atmosphere. This allows oxygen to mix with the water and so increases the dissolved oxygen content of the water. The increased available oxygen in the water makes aerobic decomposition possible.	H8, H14
Question 7 B The presence of copper ions is possible due to the colour of the substance's solution and the colour produced by the flame test.	H8
Question 8 D No visible reaction with sodium chloride solution is a possible result for a range of different salt solutions. Many common copper salts are blue or green in colour to produce aqueous solutions of similar colours. The flame test for copper ions produces a green flame.	H8
Question 9 B It is the only process producing smaller molecules.	H9
Question 10 C By definition, oxidation always occurs at the anode, reduction at the cathode.	H8
Question 11 D Fermentation produces ethanol.	H4, H9

Part A (Continued)

Answer and explanation	Outcomes assessed
Question 12 A It is balanced for mass and atomic number. None of the others are balanced.	H10
Question 13 A Of the alternatives provided, this would be the most useful because the titration values were so close.	H12, H14
Question 14 C There must have been an error in preparation of the solutions as titration is a suitable method.	H11
Question 15 B Membrane filters have pores smaller than microorganisms. C is a true statement, but is not the reason why microorganisms are removed.	H3

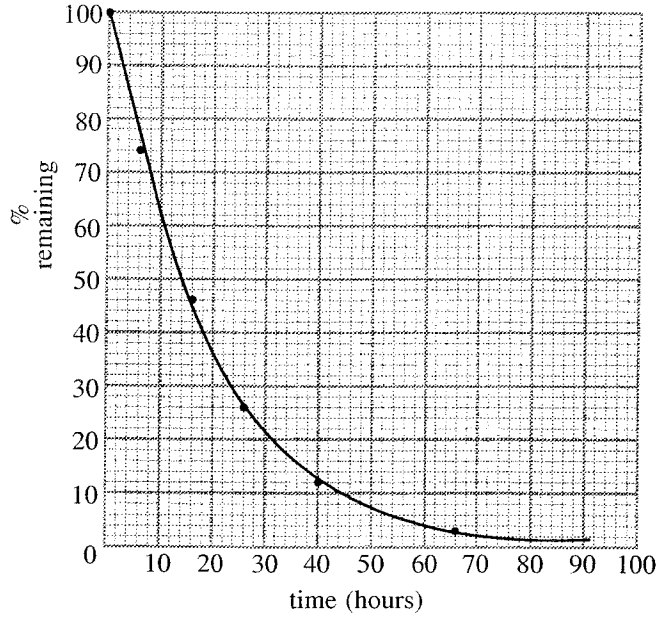
Part B

Sample answer	Syllabus outcomes and marking guide
Question 16	
This process makes use of an electric current that is supplied to reduce the ions of the metal that is to be purified. Therefore the production of the metal occurs at the cathode. Using copper refining as an example, blister copper, which is impure, is placed as the anode of such a cell. A sheet of pure copper is used as the cathode. The electrolyte used is copper sulfate solution. As the electric current flows, the metals at the anode oxidise; the copper oxidises as follows: $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$ Therefore, copper acts as the reductant. Impurities in the blister copper, such as silver and gold, which require a greater voltage to oxidise, fall to the bottom of the cell as sludge. Other impurities that do oxidise, such as iron and zinc, remain in the electrolyte as ions. At the cathode, the solid copper is formed as follows: $Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$ Therefore, copper ions act as the oxidant.	H6, H7, H13 • Detailed outline of a process, identifying oxidant, reductant and electrolyte used AND using relevant equations . . . . . 4 • Detailed outline of a process AND either identifies oxidant, reductant and electrolyte used or uses relevant equations OR • Brief outline of a process, identifying oxidant, reductant and electrolyte used, AND using relevant equations . . . . . 3 • Brief outline of a process AND either identifies oxidant, reductant and electrolyte used or uses relevant equations . . . . . 2 • Brief outline of process 1
Question 17	
(a) $n(H_2) = \frac{4.68}{24.47} = 0.19$ mol	H10 • Correct calculation (with or without unit) 1
(b) by molar ratio, NaOH : H_2 = 2 : 1 $\therefore n(NaOH) = 2 \times 0.19 = 0.38$ mol $\therefore n(OH^-) = 0.38$ mol $[OH^-] = \frac{0.38}{1.2} = 0.32$ mol L^{-1} $pOH = -\log_{10}[0.32] = 0.50$ $\therefore$ pH of water = 13.50	H10 • Correct calculation showing appropriate working . . . . . 3 • Correct answer with incomplete working . . . . . 2 • Correct answer (no working) OR • Appropriate working with calculation error 1
Question 18	
(a) $H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$	H13 • Correct equation 1
(b) In a buffer solution, the concentration of the weak acid and its conjugate base is considerably greater than the concentration of the H^+. In this case if a small amount of acid were added, the extra H^+ added would react with the HPO_4^{2-} ion forcing the equilibrium to shift to the left. However, since the $[HPO_4^{2-}]$ is so much greater than the $[H^+]$, then the original amount of H^+ remains virtually unchanged. The volume change is very small and so the new $[H^+]$ is almost identical to what it was before the acid was added. Therefore, the pH remains almost the same.	H8 • Detailed explanation (cause and effect) with reference to the equation in part (a) . . . . . 3 • Brief explanation with reference to equation . . . . . 2 • Brief explanation with no reference to equation 1

Part B (Continued)

	Sample answer	Syllabus outcomes and marking guide
Question 19		
(a)	Sodium hydroxide deliquesces when exposed to moisture. Therefore as it is being weighed its mass increases as it absorbs moisture. Since it is not possible to know how much moisture it has absorbed, the mass measurement is inaccurate.	H11, H12 • Sodium hydroxide reacts with the atmosphere 1
(b)	The sodium carbonate can be stored in a desiccator.	H12 • Keep sodium carbonate in a dry environment 1
(c)	The accuracy of the titration will not be affected. This is because the moles of the reactant transferred from the pipette into the conical flask is unaffected by the volume of water already in that flask.	H10 • States moles of reactant is unaffected with explanation . . . . . 2 • States moles of reactant is unaffected with no explanation 1
(d) (i)	The concentration of ions at the beginning of the titration is at a maximum, hence there is maximum electrical conductivity. As the solution from the burette is added, neutralisation begins to occur. This effectively decreases the concentration of the ions and therefore the electrical conductivity of the solution will also decrease.	H10 • Relates maximum conductivity to maximum concentration of ions AND relates decrease to decreasing concentration of ions . . . . . 2 • Relates maximum conductivity to maximum concentration of ion OR • Relates decrease to decreasing concentration of ions 1
(ii)	At minimum electrical conductivity, the equivalence point has been achieved. However there are still ions present from the salt produced by the reaction, therefore there is still some conductivity possible.	H10 • Relates minimum conductivity to equivalence point and minimum concentration of ions 1
(iii)	As solution from the burette is still being added to the reaction mixture, but there are no further ions available for reaction, the concentration of the ions in the solution increases and hence so does its electrical conductivity.	H10 • Relates increasing conductivity to increasing concentration of ions 1
Question 20		
(a)	$[H_3O^+] = 10^{-3.5}$ mol L^{-1} (or 3.2×10^{-4} mol L^{-1})	H10 • Correct calculation 1
(b)	HX is a weak acid, as the concentration of H_3O^+ is much lower than that of the acid, indicating that it has only partially ionised.	H2 • States HX is a weak acid AND has partially ionised since its pH is greater than 1 . . . . 2 • Poor explanation 1
(c)	X^- is a strong conjugate base compared to the weak acid HX. X^- will then ionise water to produce OH^- ions, so the solution will be basic. $X^- + H_2O \rightarrow HX + OH^-$	H8 • States solution is basic AND shows production of OH^- ions . . . . . 2 • States solution is basic OR • Shows production of OH^- ions 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 21	
(a)  half-life = 14 hours	H6 • Correct graph, fully labelled with plots visible AND correct half-life from curve . . . . . 3 • Poor curve or labelling AND correct half-life from curve . . . . . 2 • Curve only OR • Half-life only 1
(b) Yes, as the isotope has a short half-life (will not be in the body for long) and produces gamma radiation able to be detected outside the body (or which is able to kill cancerous cells).	H6, H8 • Yes, justified by short half-life AND a gamma emitter (which can either be detected or used to kill cancerous cells). . . . . 2 • Yes, and one correct justification. 1
(c) An isotope with short half-life that emits gamma rays, such as strontium-92 (half-life 2.7 hours), technetium-99m (half-life 6 hours), iodine-121 or 123.	H6 • An isotope with short half-life that emits gamma rays 1
Question 22	
Radioisotopes have impacted our lives significantly. The positive benefits include: • improved life-spans in humans by using caesium-137 to treat tumours and technetium-99 for imaging body systems; • improved environmental understanding by using scandium-46 to follow silt movement in rivers or californium-252 to find water in soil. Negative effects include: • cell mutation and genetic mutation; • warming of waterways from nuclear reactors; • nuclear war.	H4 • Analyses impact of radioisotopes AND has appropriate examples of positive and negative effects in industry and medicine. . . . . 4–5 • Examples of positive and negative uses in industry and in medicine; but little or no analysis OR • Analysis but insufficient examples . . . . . 2–3 • Some examples but not one of each for positive and negative OR • Some analysis with no examples 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 23	
Thermoplastic polymers have weak dispersion forces between their chains, leading to lower melting points and allowing the polymer to be easily moulded and reshaped by simply heating it until it is soft enough. The chains slide easily past each other due to the lack of strong forces between them. Examples include polystyrene and polyethene, which are used for food storage and containers. The containers are easily shaped while heated in the moulds.	H3, H9 • States heating disrupts the weak forces between chains, allowing chains to slide past each other AND remoulding is possible through heating AND names an example AND relates its use to the property 4
	• States heating disrupts the weak forces between chains, allowing chains to slide past each other AND remoulding is possible through heating OR • Names an example AND relates its use to the property 3
	• Gives some indication of softening being related to forces between chains, but lacks detail AND gives an example 2
	• Names and example..... 1
Question 24	
A natural biopolymer is cellulose. A biopolymer which is produced synthetically is rayon, made from regenerated cellulose (wood pulp or cotton). The purified cellulose is treated with NaOH and broken up, then further reacted with CS_2 and NaOH to form a viscose solution, which is forced though the holes of a spinneret whilst reacting with H_2SO_4. As they react, the fibres harden and are spun onto spools for use as fibres in fabrics. Biopolymers benefit society as they reduce our dependence on fossil fuels but are produced from living organisms. They are biodegradable, leading to less pollution in our environment.	H1, H4 • Names one natural biopolymer AND one artificially produced biopolymer AND describes production of artificial polymer AND explains the benefits of biopolymers for society 4–5
	• Names one natural biopolymer AND one artificially produced biopolymer AND partially describes production of artificial polymer AND partially explains the benefits of biopolymers for society..... 2–3
	• Names one natural biopolymer AND one artificially produced biopolymer :..... 1

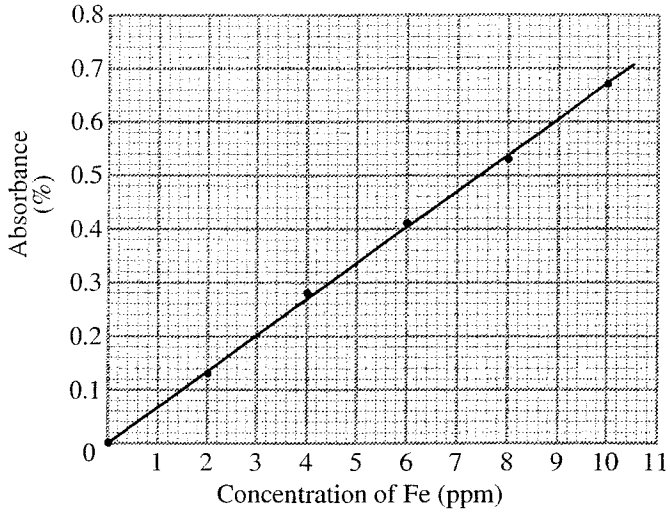
Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 25	
(a) There is a relatively high number of coliform bacteria in the water sample from the river. This large number of bacteria would require a large amount of oxygen and so a decreased amount of oxygen would be present in the water.	H8, H13 • Links low dissolved oxygen to high bacteria count AND therefore high demand for oxygen . . . . . 2 • States low dissolved oxygen due to high bacteria count OR • States a high demand for oxygen. 1
(b) The high number of coliform bacteria require a large amount of oxygen, therefore the biochemical oxygen demand is relatively high. The demand will continue to increase as the bacteria reproduce. As a result, other organisms will die. There is also a possibility of eutrophication.	H8, H13 • Predicts biochemical oxygen demand will be high (and increase) AND that other organisms will suffer . . . . . 2 • Predicts biochemical oxygen demand will be high OR • Predicts other organisms will suffer. 1
(c) Based on the values shown, this river would not provide an appropriate environment to grow oysters. The amount of oxygen is too low because the bacterial levels are too high. Also, these bacteria are toxic and so could infect the oysters; this could increase the risk of food poisoning.	H8, H13 • States that river is unsuitable for growing oysters with justification . . . . . 2 • States that river is unsuitable for growing oysters 1
Question 26	

Concentration	*Concentration in River A relative to River B*	*Explanation*
Dissolved O_2	higher	No eutrophication indicates lower oxygen requirement by aquatic organisms.
Phosphate ion	lower	Lack of phosphate would decrease the probability of eutrophication.
Lead ion	same	The presence of lead ions would have no effect on eutrophication.

H8
• Correctly predicts relative concentrations AND accounts for relative values 4
• Correctly predicts relative concentrations AND accounts for relative values of either oxygen or phosphate 3
• Predicts some relative concentrations AND partially accounts for relative values 2
• Partially completes table 1

Part B (Continued)

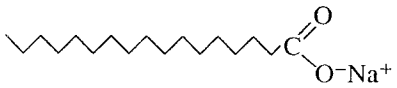
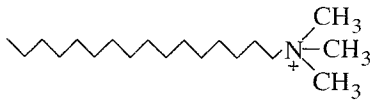
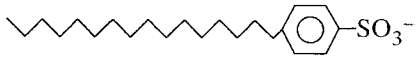
Sample answer	Syllabus outcomes and marking guide
Question 27	
(a) 	H10 • Correct graph 1
(b)	H10 • Correct sample value, i.e. multiplying by the dilution factor. . . . . 2 • Reading values from graph 1

Engine number	*Absorbance* (%)	*Diluted [Fe]* (ppm)	*Sample [Fe]* (ppm)
X12	0.04	0.6	$20 \times 0.6 = 12$
X45	0.01	0.1	$20 \times 0.1 = 2$
X67	0.30	4.5	$20 \times 4.5 = 90$

(c)	The first two engines are showing little dissolved iron and as such have no problems but the third has a significant amount probably due to rusting of iron components in the engine.	H14 • Feasible hypothesis for all engines . . . . . 2 • Feasible hypothesis for any one engine . . 1

Section II

Question 28 Industrial Chemistry

	Sample answer	Syllabus outcomes and marking guide
(a) (i)	$K = \dfrac{[N_2O_4]}{[NO_2]^2}$	H10 • Correct equilibrium expression (no units required) 1
(ii)	An equilibrium constant is a constant at a particular temperature. If temperature is increased, exothermic reactions will have a decrease in the value of K_c and endothermic reactions will have an increase. For a temperature decrease the reverse is true.	H8, H10, H13 • States equilibrium constant value increases with temperature for an endothermic reaction and decreases for an exothermic reaction ..... 2 • Temperature changes the value of the equilibrium constant 1
(b) (i)	$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$ $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ $SO_{3(g)} + H_2SO_{4(l)} \rightarrow H_2S_2O_{7(l)}$ $H_2S_2O_{7(l)} + H_2O_{(l)} \rightarrow 2H_2SO_{4(l)}$	H13 • Provides correct chemical equations for production of SO_2, conversion to SO_3, production of oleum AND dilution of oleum with water ..... 2 • Any two of the above equations 1
(ii)	The reaction is exothermic therefore lower temperatures favour the formation of SO_3. An excess of O_2 gas is used to drive the equilibrium to the right. Higher pressures favour the formation of SO_3 as the total number of molecules is reduced.	H7, H10, H11, H13 • Correctly identifies and describes two conditions used to maximise yield ..... 2 • Correctly identifies two conditions used to maximise yield OR • Identifies one condition and describes how it affects the yield 1
(c)	Soaps consist of a long chain fatty acid with a hydrophilic head,  whereas a synthetic detergent is industrially manufactured and may be cationic,  or anionic,  or non-ionic. Many detergents contained phosphates (e.g. $P_3O_{10}^{5-}$) as "builders" which aid in detergent action by acting as water softeners but cause problems in rivers as they promote algal growth. The algal growth leads to a depletion of oxygen in the river and eventually the water becomes "dead". Soaps tend to "break down" in the environment but early detergents were very persistent because they contained branched hydrocarbons. This cause excessive frothing which was unacceptable. Later detergents were developed with straight chain hydrocarbons which are more easily biodegradable.	H13, H16 • Describes the structure of a soap and a detergent AND compares the biodegradability of soap and detergent AND discusses the generational change of detergents AND discusses the problem of phosphate in waterways AND contrasts the effects of soap and detergent in the environment ..... 4–5 • Describes a soap and a detergent; discusses and compares an environmental impact of soap and detergent ..... 3 • Describes either a soap or a detergent; identifies an environmental issue ..... 2 • Describes either a soap or a detergent OR • Identifies an environmental issue with soap or detergents 1