NSW INDEPENDENT TRIAL EXAMS – 2003

HSC CHEMISTRY - SUGGESTED ANSWERS

PART A

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

PART B.

16. (a) eg., polyethylene which is made by heating ethylene monomer with a suitable catalyst, so that the electrons from the ethylene double bond link ethylene molecules into long strands 2
    (b) the weak dispersion forces between the polymer strands yield a soft and flexible plastic which is easily moulded, making it suitable for food containers, plastic bags and plastic film for food wrapping. 2
17. (a) CH_3CH_2OH or expanded formula 1
    (b) $C_2H_{4(g)} + H_2O \rightarrow C_2H_5OH$ The catalyst can be sulfuric or phosphoric acid 2
    (c) Ethanol is a polar molecule with an OH group providing hydrogen bonding. Thus it is a good solvent for other polar organic molecules, including lacquers, dyes, perfumes and food flavourings. It also is fully soluble in water, as in alcoholic drinks. 3
18. (a) $Zn_{(s)} + Pb^{2+} \rightarrow Zn^{2+} + Pb_{(s)}$ 1
    (b) Cell voltage = 0.76 – 0.13 = 0.63 V 1
    (c) eg., the dry (Leclanche) cell which has widespread use, providing a cheap source of power for nightime illumination, in electric torches, and for many portable electronic devices such as radios, CD players and toys. Disadvantages include its bulk, limited shelf life and possible leakage causing damage to equipment. 3
19. (a) eg., ^{99}Tc is made using neutrons from a reactor to bombard ^{98}Mo. After absorption of the neutron the Mo nucleus emits a beta particle, forming ^{99}Tc 2
    (b) This isotope is used in medicine to trace the blood flow in the body, for example in the retina of the eye, allowing diagnosis of damaged blood vessels. It has a very short half-life, so must be used immediately, but this also limits the radiation exposure of the patient. As with all radioisotopes some tissue damage occurs from its gamma radiation. 3
20. (a) The leaves were chopped into small pieces, and placed in hot water to extract the purple dye. The solution was decanted and allowed to cool. A range of solutions was tested by adding a few drops of the cabbage dye to each. 2
    (b)

Subtance	water	ammonia soln.	vinegar	drain cleaner
Dye Colour	blue	green	red	yellow

2

21. (a) Moles of sulfur = 43.5/32 = 1.35 mol
    Moles of SO_2 formed = 1.35 mol
    Volume of SO_2 formed = 1.35 x 24.79 = 33.47 L 3
    (b) Combustion of the lignite releases SO_2 into the atmosphere. This gas causes breathing difficulties for some people. It also undergoes oxidation to SO_3 which dissolves in rainwater to form sulfuric acid. Acid rain causes many problems including corrosion of metals and building materials, damage to plants and aquatic systems such as freshwater lakes and release of heavy metals by accelerated weathering of rocks. 3
22. (a) sodium hydroxide absorbs both water and carbon dioxide from the air, so that it cannot be used as a primary standard. Titration is needed to determine its concentration. 1
    (b) [NaOH] = 23.2 x 0.100/25.0 = 0.0928 mol L^{-1} (mole ratio HCl:NaOH = 1:1) 2

Q22 (c) Titration procedure to include use of pipette for NaOH solution, burette for HCl, conical flask and suitable indicator such as phenolphthalein. All glassware to be rinsed with distilled water, followed by the solutions for the pipette and burette. 2

Titration carried out with swirling of flask contents, with the end point recorded as the volume of HCl to decolorise the indicator. Rinse flask with distilled water after each titration.

Minimum of three titration measurements, with two agreeing within 0.1 mL. 2

23. (a) eg., ethyl acetate (ethanoate) $CH_3CH_2OCOCH_3$ or expanded structural formula 2

(b) The reaction is slow and requires and is carried at by boiling with a catalyst. As the reactants and product are volatile, and highly flammable, a reflux condenser is needed to continuously condense the escaping vapour and return the condensate to the reaction flask. 2

24. A buffer is a solution which maintains almost constant pH when small quantities of acid or base are added. The buffer consists of a weak acid and its conjugate base, at roughly equal concentrations.

An example is our blood, which is buffered by the presence of the hydrogen carbonate ion, maintaining a stable pH as it circulates though the body. 3

25 (a) Add a few drops of dilute silver nitrate solution. If chloride ion is present a white ppte. of AgCl forms. 1

(b) Nitrate ion may come from run-off from gardens and farms that have had nitrate fertiliser applied. 1

(c) eg., sodium ion, which causes health problems in drinking water, including increasing blood pressure and the risks of circulatory diseases. 2

(d) The chlorine acts as a disinfectant by destroying bacteria and other microbes, including those which can cause diseases such as cholera, typhoid and dysentery. 2

26. (a) $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ 1

(b) The data in the table show that increasing the temperature reduces the equilibrium concentration of ammonia, forcing the equilibrium to the left. Hence the forward reaction is exothermic. 2

(c) Increasing pressure increases % ammonia yield, at all temperatures. This is confirmed by the stoichiometry of the reaction with 4 moles of gaseous reactants forming 2 moles of gaseous products –hence an increase in pressure favours the side of fewer gaseous molecules. 2

(d) High pressure increases the equilibrium yield of ammonia. A temperature of 300-400 deg. is a compromise to establish equilibrium quickly, and still obtain an acceptable yield of ammonia. 2

27. (a) The presence of a relatively high concentration of calcium and/or magnesium ions. 1

(b) Either test the lathering qualities of the water with soap, which will form a non-lathering scum (precipitate) with hard water, or add carbonate ions, which form a white ppte. of $CaCO_3$ with Ca^{2+} ion. 2

Section II Options:

Q28. Industrial Chemistry

(a) (i) The equilibrium constants ($k = [HI]^2/[H_2][I_2]$ are:

Exp 1 = 45.9, Exp 2 = 19.4, Exp 3 = 45.4

Experiments 2 was carried out at a lower temperature, as the forward reaction is endothermic, meaning that K decreases with decreasing temperature. 2

(ii) Observe the purple colour (iodine gas) of the mixture. When the intensity is constant the system is at equilibrium. 1

(iii) The equilibrium moves to the right, increasing [HI]. The value of K is the same. 2

(b) A mixture of sodium hydroxide solution and olive oil is maintained at its boiling point for about 20 minutes, or until the oil layer has dissolved. After cooling, concentrated salt solution is added to precipitate the soap, which is separated and washed in a little water. The soap is tested by shaking a small amount in a test tube of water, to observe its lathering effect. 4

(c) (i) $S(g) + O_2(g) \rightarrow SO_2(g)$ 1

(ii) The sulfur is mined from natural deposits by the Frasch process. 1

(iii) eg., in making detergents, superphosphate, explosives etc. or as battery electrolyte 1

(d) Synthetic detergents use the SO_3^- as the hydrophilic part of the molecule, while soaps contain the carboxyl COO^- group. Soaps are ineffective in hard water as they form an insoluble precipitate with calcium or magnesium ions. Synthetic detergents do not form a precipitate and so are effective for cleaning in hard water. 3

(e) (i) 3,4,2,1 2

(ii) carbon dioxide and ammonia 2

(f) eg., natural rubber (latex) is collected as sap from bark of rubber trees. The supply of latex is inadequate to meet the huge demand for rubber, for auto tyres, and can be interrupted by political upheavals.
Synthetic rubber has largely replaced latex. As an addition polymer based upon styrene and butadiene, synthetic rubber has many advantages over the natural product. With fewer double bonds in the vulcanised product it deteriorates more slowly. By modifying the side groups on the polymer chain a variety of rubbers with specialised properties has been obtained. for example, in neoprene, the use of Cl atoms in place of methyl groups yields a strong, flexible and chemical resistant rubber. 6

Q29. Shipwrecks, Salvage & Conservation

(a) (i) Iron will corrode, as it has the more negative E^o 1

(ii) soft and malleable (mild) steel with less than 0.2% C
hard steel with 0.3 to 0.6% carbon
hard, high strength with 0.6 to 1.3% carbon 3

(b) Rusting occurs in the presence of water and oxygen.
Iron oxidises to Fe^{2+} in an anodic region of the metal, while oxygen is reduced to hydroxide ions at a cathodic region. Fe^{2+} reacts with OH^- ions to form $Fe(OH)_2$ precipitate.
Oxygen further oxidises the $Fe(OH)_2$ to $Fe(OH)_3$ which is the approximate composition of rust. 4

(c) (i) The rate of electrolysis of a solution of copper sulfate was observed, varying the composition of the electrodes (carbon and copper), the electrode separation, the concentration of the solution and the applied voltage. 3

(ii) The rate of electrolysis increased as the concentration of the solution and applied voltage increased, and as the electrode separation decreased. 2

(d) (i) Artefacts accumulate mineral salts such as chlorides and sulfates, which reach saturation if exposed to air which allows evaporation. 1

(ii) sulfate-reducing bacteria obtain energy by reducing SO_4^{2-} to H_2S, using electrons from the oxidation of iron metal to Fe^{2+}. The Fe^{2+} reacts with water to form $Fe(OH)_2$ 2

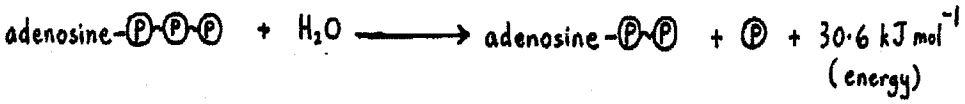
(iii) eg., salt-saturated artefacts are washed with water or dilute sodium hydroxide solution. Concretions are removed by soaking in a very dilute acid bath to dissolve carbonates. Electrolysis, with a metallic artefact as the cathode, is used to remove chloride ion and to reduce encrusted salts back to the metal. 3

(e) Galvani showed that the muscles of a frog twitched when two different metallic wires were joined at one end, and the free ends placed on the exposed muscle. He thus became the first person to create an electric cell, and showed the electrical nature of the nerve-muscle action.
Volta showed that the electric effect came from the two wires in a solution and made the first galvanic cell, and increased the voltage by joining cells in series, forming a battery.
Davy used Volta's battery to perform electrolysis experiments, decomposing water and many other substances, including melted NaOH and KOH, obtaining these metals for the first time.
Faraday developed the idea of current as a flow of electric charge, made accurate measurements of the electric charge and masses of substances formed in electrolysis, and put forward the laws of electrolysis. 6

Q30. Biochemistry of Movement

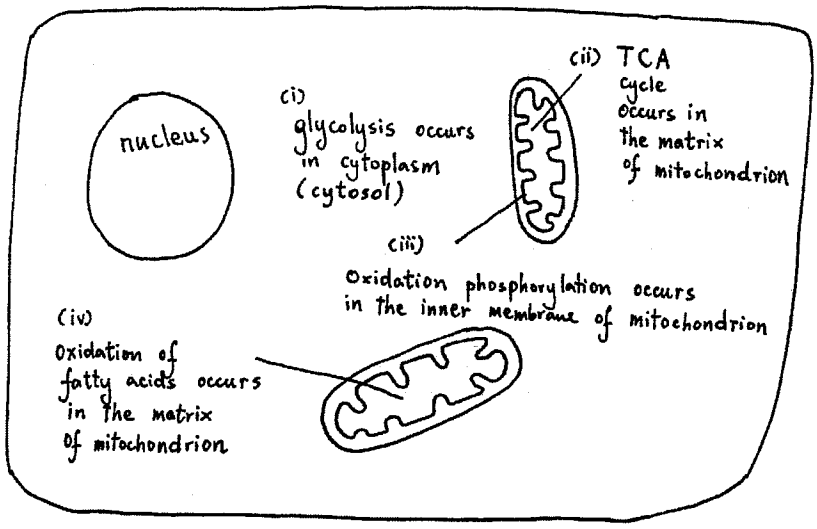
(a) (i) Adenosine triphosphate (ATP) 1

(ii) $ATP + H_2O \rightarrow ADP + P + \text{energy}$ OR



2

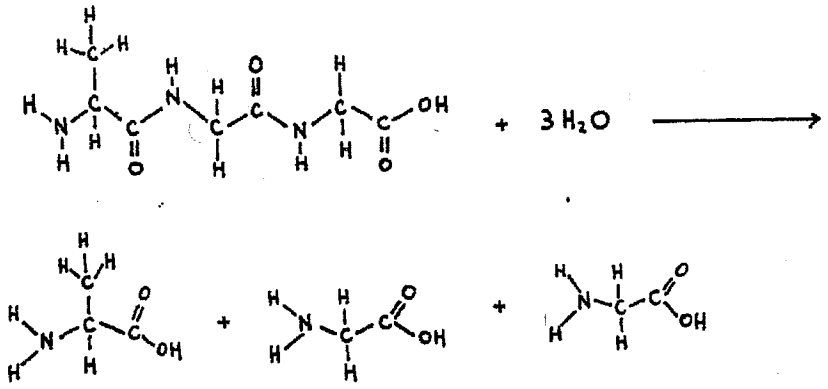
(b)



4

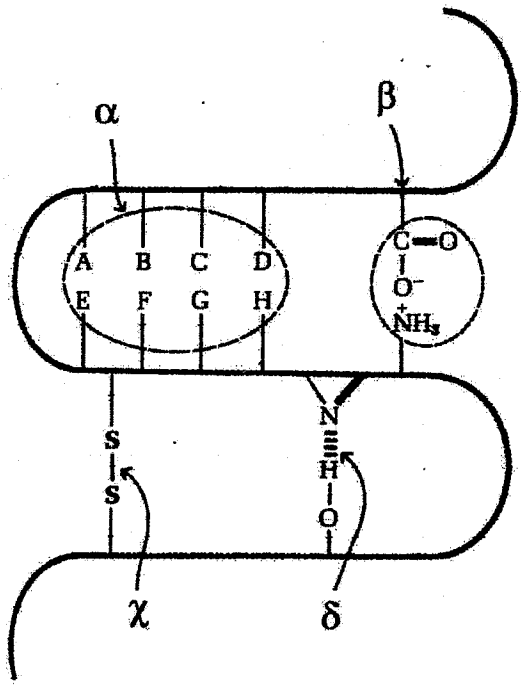
(c) (i) (overleaf)

(c) (i)



3

(ii) 1 mark for each interacting force and 1 mark for mentioning the significance of tertiary structure. 3



(d) eg., the effect of temperature on the enzyme action of peroxidase, including method of varying temperature and measuring the activity of the enzyme.
Discuss the effect of pH or temperature in denaturing the enzyme by altering or destroying its tertiary, and secondary structure. 6

(e) A nerve impulse triggers the release of acetyl choline which in turn releases calcium ions over the actin and myosin protein fibres which comprise the muscle filaments.
The calcium ions activate the formation of myosin bridges which become attached to the actin filaments. An actomyosin cross-bridge is formed. This can be described as the formation of temporary bonds between the actin and myosin.

ATP is then hydrolysed leading to a change in the angle of the cross-bridge such that the myosin head pulls the actin filament over itself towards the centre of the sarcomere.

ATP $\rightarrow$ ADP + Pi + energy for muscle contraction

With all myofilaments acting in this way during sarcomere stimulation the end result is the generation of a force which may lead to a shortening of the sarcomere length. 6

Q31. Chemistry of Art

(a) These colours reflect the minerals which were available, and which could be obtained by grinding and mixing with natural resins. Reds, yellows and intermediate shades came from ochres which are forms of hydrated iron oxide. Black was produced from pyrolusite and white from kaolin (clay), chalk or gypsum 3

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ 1

(ii) As electrons are successively removed the ionisation energy increases, as the electrons are being removed from an increasing positive charge. There is a large increase between the 4th and 5th electron as the latter has to be taken from the much lower n=2 level. 2

(iii) Electronegativity is the attraction of an atom for electrons 1

(iv) Electronegativity increases from left to right across a period, with increasing numbers of outer shell electrons. The electrons are more strongly attracted to the increasing positive charge on the nucleus. 2

(c) eg., the changes in oxidation states of chromium or manganese as reduction from their highest oxidation states takes place in acidic or alkaline conditions. Describe conditions and the variation in colour observed such as for Mn from 7 (purple) to 5 (green), to 2 (colourless). 4

(d) Laser spectral analysis is used to determine the composition of the pigments used in a painting, as a step towards restoration. The technique is a destructive one, so must be use with care on small samples removed from unobtrusive areas.
A high energy pulse of laser light vaporise the pigment ample. the vapour is then passed between high voltage electrodes which excite the atoms. As electrons fall to their ground states the spectral lines emitted identify the elements present, and assist in determining the composition of the pigment. 6

(e) In the aqueous state eg., Cr^{3+} ion is tightly surrounded by six water molecules, the hydrated ion comprising a complex ion, or coordination complex. This arises because the water molecules are polar and have unshared pairs of valence electrons, which form coordinate covalent bonds with the chromium ion, itself having vacant orbitals in the valence shell.
The colour of the ion results from the closely spaced energy levels in the partially filled d-orbitals. Quanta of light are absorbed at specific energies, the observed colour being that of the unabsorbed light which is reflected or transmitted. 6

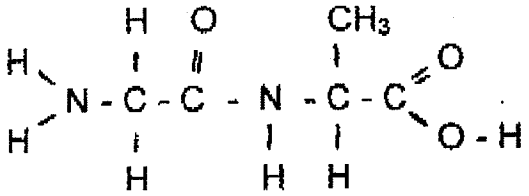
Q32. Forensic Chemistry

(a) (i) The molecular formula can be written as $C_6(H_2O)_6$ which follows the general formula for carbohydrates of $C_x(H_2O)_y$ 1

(ii) glucose + fructose → sucrose + water 1

(iii) glucose is easily oxidised and reduces oxidants such as Benedict's solution. Sucrose is much harder to oxidise and has no reaction with Benedict's solution. 2

(b) (i)



2

(ii) In electrophoresis a piece of porous paper, soaked in buffer solution is spotted with each of the substances to be tested. An electric field is applied between conducting plates. At pH 6 the alanine is a neutral and does not move in the field. Aspartic acid is negatively

charged at pH 6 and migrates towards the positive electrode. The final position of each protein can be observed by spraying an indicator onto the paper. 2

(iii) The pH would need to be either lower or higher to convert the amino acids to an ionised form. With a larger molecular mass alanine moves more slowly than glycine, and hence the two can be distinguished. 2

(c) While all humans have very similar DNA the non-coding sequences that separate a person's genes vary between individuals, making each person's DNA unique. DNA analysis involves:
> separating DNA from other materials in the sample
> Making multiple copies of the separated DNA
> using electrophoresis to determine the lengths of the DNA segments.
The DNA profile from the blood at the scene can be compared with that of a suspect. An exact match would show that the suspect was at the scene of the crime. 5

(d) Destructive testing means that the original material is lost. This can be a problem where:
> the test cannot be repeated to ensure validity.
> material may be required as physical evidence in a court case.
> the material is not available for other tests, or new testing procedures which might later be developed.
> the material may be part of a valuable object such as historic artefact or jewellery. 3

(e) (i) In a darkened room a length of platinum wire was dipped into a solution of sodium nitrate and then placed in a hot blue Bunsen flame. Intense yellow light is emitted. Observed through a spectroscope, a series of sharp, coloured lines was observed, which is the emission spectrum of sodium. 2

(ii) The Bunsen flame provides energy to excite the sodium atoms, promoting electrons from their ground states into higher energy empty orbitals. As the electrons fall back to their ground level states they lose energy in the form of light. The frequency of the light emitted is proportional to the energy transition. Each transition corresponds to a single frequency (line) in the emission spectrum. 2

(iii) Emission spectra can assist the forensic scientist by identifying the elements present in a sample, as each element has a unique emission spectrum. It may also be used to provide a quantitative analysis of these elements.
The tests can be performed on minute samples of material, leaving the bulk of the evidence material unaffected. The method also provides results quickly, important in active investigations. 3

Chemistry 2003

HSC Trial Examination Mapping Grid

Question	Marks	Content Syllabus Ref: 9.	Syllabus outcomes Outcomes H..	Targeted performance bands
1	1	2.5	3, 6	3-4
2	1	2.3	6, 9	2-3
3	1	2.3	9, 14	2-3
4	1	2.4	6, 8	3-4
5	1	2.3	7, 14	3-4
6	1	3.1	3, 14,	3-4
7	1	3.3	8, 14	2-3
8	1	3.3	6, 8	3-4
9	1	3.4	11, 12	2-3
10	1	3.4	6, 8	3-4
11	1	4.4	6	3-4
12	1	4.3	2, 14	2-3
13	1	4.3	2, 3	3-4
14	1	4.3	6, 11	3-4
15	1	4.5	4, 8	2-3
16(a)	2	2.1	8, 9	2-4
16(b)	2	2.1	4, 9	3-5
17(a)	1	2.3	6, 9, 13	3-4
17(b)	2	2.3	9, 13	3-4
17(c)	3	2.3	3, 9, 13	3-5
18(a)	1	2.4	6, 7, 13	3-4
18(b)	1	2.4	7, 8	2-3
18(c)	3	2.4	3, 4, 13	3-6
19(a)	2	2.5	3, 6	2-4
19(b)	3	2.5	4, 13	4-6
20(a)	2	1, 3.1	8, 11, 13	3-4
20(b)	2	1, 3.1	14	2-3
21(a)	3	3.2	10, 14	3-4
21(b)	3	3.2	4, 7, 13	2-6
22(a)	1	1, 3.4	8, 11	4-5
22(b)	2	3.4	10, 14	3-4
22(c)	4	1, 3.4	2, 11, 13	4-5
23(a)	2	3.5	6, 9	3-4
23(b)	2	1, 3.5	11, 12	4-5
24	3	3.4	4, 8, 13	3-5
25(a)	1	4.5	8, 11	2-3
25(b)	1	4.5	4	2-3
25(c)	2	4.5	4, 8, 13	3-5
25(d)	2	4.5	3, 8, 14	3-4
26(a)	1	4.2	8, 13	2-3
26(b)	2	4.2	8, 14	3-5
26(c)	2	4.2	7, 8	4-5
26(d)	2	4.2	3, 8, 11	4-5
27(a)	1	4.5	4, 6	2-3
27(b)	2	4.5	12, 14	3-4

Options Grid Overleaf

Chemistry 2003 Options

Option 1: Industrial Chemistry				
28(a)	5	5.1	8, 10, 12, 14	2-5
28(b)	4	5.5	9, 11, 13	3-5
28(c)	3	5.3	3, 4, 6, 13	1-3
28(d)	3	5.5	4, 9, 13	4-5
28(e)	4	5.6	3, 8	2-4
28(f)	6	5.1	3, 4, 13	3-6
Option 2: Shipwrecks and Salvage				
29(a)	4	6.2, 6.4	3, 4, 6, 8, 13	2-4
29(b)	4	6.2	4, 8, 13	2-5
29(c)	5	6.3	8, 11, 12, 14	3-5
29(d)	6	6.6, 6.7	4, 8, 12, 13	3-5
29(e)	6	6.1	1, 2, 3, 13	2-6
Option 3: Biochemistry of Movement				
30(a)	3	7.1	7, 13	2-4
30(b)	4	7.1, 7.7, 7.8	6, 7, 13	2-4
30(c)	6	1, 7.4	6, 7, 13	2-5
30(d)	6	1, 7.5	6, 11, 12, 14	2-6
30(e)	6	7.5	2, 6, 13	3-6
Option 4: Chemistry of Art				
31(a)	3	8.1	3, 4	3-4
31(b)	6	8.3	6, 13	2-5
31(c)	4	1, 8.4	11, 12, 14	2-5
31(d)	6	8.2	3, 4, 6, 13	2-6
31(e)	6	8.5	6, 13	2-6
Option 5: Forensic Chemistry				
32(a)	4	9.2	6, 9, 13	2-5
32(b)	6	9.3	6, 9	3-6
32(c)	5	1, 9.4	11, 12, 14	2-6
32(d)	3	9.5	3, 4, 11, 1, 12	2-4
32(e)	7	1, 9.6	3, 4, 7, 11	3-6