**Question & Answer** **Comment** (and relevant page in *CCHSC*)  
  **1.** A Renewable means that we can use it up then re-make it. If we burn ethanol, it goes to carbon dioxide which plants can then make into glucose and starch which we can then convert back to ethanol. The other products come from materials we dig out of the ground. While we may find new deposits of the ores, we cannot re-make the ores once they are used up.  (p 34-5)

**2.** D When glucose molecules combine to form cellulose, a molecule of water is released between each pair of glucose molecules. That by definition is a condensation reaction. An addition reaction involves two or more molecules joining together without the release of any atoms; polymerisation of ethylene to polyethylene is an addition reaction.  (p. 22-3,  8-13)

**3.** B In a galvanic cell electrons flow through the external circuit (a wire) while ions flow through the salt bridge, so that eliminates A and C. The anode is the electrode where oxidation occurs so at the anode electrons are released to the external circuit and flow through it (the wire) to the cathode where the reduction reaction absorbs them.

**4.** None of the four answers is correct.  
 The IUPAC name of the given compound is 3-heptanol. C is probably the answers the examiners want. It is the name used in an alternative naming system used in some important chemical journals but it is not the IUPAC name.  (p 12 and *CCPC* p 267)

**5.** D You need to look up the standard electrode potentials and subtract the two values for each pair. The question is about the *magnitude* of the value not its sign.  (p 68-70 particularly equation 2.14)

**6.** C You need to know that phenolphthalein changes from colourless to pink as alkalinity (pH) increases. The only alkaline solution here is NaOH.  (p 109, 139)

**7.** D You need to know that neutralisation reactions are exothermic, meaning that *H* for them is negative. D is the only graph with a negative *H*.  (p 157)

**8.** C From the information given both acids are weak. Only strong acids are completely ionised so A is incorrect. X will be ionised to a greater extent than Y so B is incorrect. If X is ioinised to a greater extent than Y, it produces a greater concentration of H+ ions which means that it has a lower pH, so C is correct. Both acids require the same amount of NaOH for neutralisation: strength does not affect this.  (p 140-2)

**9.** A Citric acid is a weak acid so the citrate ion is a weak base, so a solution of citrate will hydrolyse (react with water) to a small extent to form citric acid and OH–. These OH– ions will make the pH > 7.  (p 152-4) **10.** C To change pH from pH 1.0 to 2.0 we need to change H+ concentration from 0.1 mol/L to 0.01 mol?=/L, that is dilute it by a factor of ten, so 90 mL needs to go to 900 mL so 810 mL needs to be added. Answer D was for students who knew what the question was about but did not read it carefully enough.  (p 135)   
**11.** B Something you need to know – the definition of hardness.  (p 277)  
 **12.** A Fossil fuels are coal, oil and natural gas (and oil shales and tar sands). They all contain carbon and hydrogen so when burnt, normally produce carbon dioxide and water. Sulfur dioxide is only produced if there is sulfur in the fuel, often but not always the case. Carbon (soot) is produced during incomplete combustion which does not always happen. Hence B and C are wrong. But which of A and D is correct? The examiners' report gives A as the answer. I guess it is possible to burn a fossil fuel without producing carbon dioxide – by just producing carbon monoxide with or without some soot, but it is highly unlikely that no CO2 would be produced. If the fossil fuel contains hydrogen – and all of them do – it will end up as water so I guess that makes A the correct answer. Maybe the question is trying to combat the popular misconception that coal is carbon rather than being a mixture of compounds which are predominantly carbon but which also contain hydrogen (and often nitrogen and sulfur). If coal is heated in the absence of air it decomposes to volatile gases (formerly used as town gas) and a porous solid called coke that is virtually pure carbon. When coke is burnt it produces only carbon dioxide (no water), but I guess coke is not a fossil fuel but rather a product made from a fossil fuel. Frankly I do not like this question: It seems to be nitpicking rather than testing chemical understanding.  (CCPC p 247-8, 268-9)  
 **13.** A By Le Chatelier's principle a decrease in pressure will cause the reaction to move to the left (to generate more moles of gas to try to resist the pressure drop) so B and C are incorrect. The reaction releases heat as it goes from left to right (*H* negative), so it absorbs heat as it goes from right to left so A is the answer. D is awkwardly worded: does it mean *the rate of the reverse reaction will decrease*?  (p 117-8)   
**14.** D You need to know that in AAS the wavelength of light used is one that is absorbed by the element being analysed for. This means that it is one that is emitted when the element falls back to its ground state after being excited in a flame test. It is this choice of wavelength that makes AAS so particularly sensitive. AAS is quantitative; in fact it is not much good for qualitative analysis because a different lamp (light source) is needed for each element being detected.  (p 224-7)   
**15.** B The net result of the two given reactions is  
O + O3    2O2    
The Cl is consumed in the first step but regenerated in the second so overall it is not used up. This is a requirement of a catalyst. It also brings about or speeds up the overall reaction, the other requirement of a catalyst.  (p 253, *CCPC* p 291, 296-8)

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| **Question 16** (5 marks) |  |  |
| Factual material you need to know.      For part (b), effects, there are 4 marks so you need at least four bits of information. Mention that the effects are beneficial in the stratosphere but harmful in the troposphere. (p 235-6, 238) | **(a)** | X troposphere; Y stratosphere |
| **(b)** | In the stratosphere the effect of ozone is to absorb short wavelength ultraviolet (uv) radiation that is present in sunlight . In doing this it protects humans and most other life forms from the quite harmful effects of this short wavelength uv radiation. In the troposphere ozone is naturally present at extremely low and harmless concentrations, but in densely populated urban areas it can be formed at much higher concentrations and then becomes a serious pollutant. Its harmful effects are to cause respiratory problems in humans and other animals, to damage plants and inhibit their growth and to damage some materials such as rubber (causes cracking). |
| **Question 17** (4 marks) |  |  |
| Complete ionic or net ionic equations would be equally acceptable. (p213) | **(a)** | Na2CO3(*aq*) + 2HCl(*aq*)     2NaCl(*aq*) + H2O(*l*) + CO2(*g*) |
| You only need to give the answers, not your reasoning which is as follows:      Sodium carbonate and hydrochloric acid solutions are the only combination that produces a gas. Hence Solutions 1 and 2 must be sodium carbonate and hydrochloric acid though we do not yet know which is which. Lead ions produce a white precipitate with both sodium carbonate and hydrochloric acid  (with CO32– and Cl– anions), whereas barium ions produce a precipitate only with carbonate (not with Cl–). Hence solutions 2 and 4 must be barium nitrate and hydrochloric acid, so 2 is HCl and 4 is Ba(NO3)2. This means that 1 is sodium carbonate and 3 is Pb(NO3)2.   (p 206-8) | **(b)** | Solution 1 is sodium carbonate              2 is hydrochloric acid              3 is lead nitrate              4 is barium nitrate |
| Perhaps you could mention that lead is poisonous and so we should not try to vaporise lead solutions/ (p 216) | **(c)** | Of the four solutions only Na+ and Ba2+ have characteristic flame colours. Hence while flame tests would identify barium nitrate, they could not distinguish between lead nitrate and hydrochloric acid.  (in addition sodium has such an intense flame emission that even very small amounts of sodium present in other solutions as a contaminant could lead to a positive flame test; a flame test for identifying sodium is not very reliable.) |

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| **Question 18** (3 marks) |  |
| Wow!  Describe the role of a chemist ... and describe  a chemical principle used ... for just 3 marks (that is, in just 5 minutes). That is really asking a lot. You need to choose a chemistry job that can be described briefly and that uses a chemical principle that also can be described briefly.     The exam paper suggests that five lines should be sufficient for this task. However there is considerable blank space below that if you need it (as you probably will).      Note that you are asked to describe a chemical principle, not describe the technique used. (p 195-7) | My chemist works in an analytical laboratory analysing samples for law enforcement agencies and for anti-drug units attached to various sporting bodies. The job is to analyse samples to determine what, if any, illegal drugs are present and if so, in what concentrations. The main techniques used are gas chromatography and high pressure (performance) liquid chromatography. One of the chemical principles involved is solubility, the tendency of the compounds being analysed to dissolve in the non-volatile liquid adsorbed on the solid packing or on the walls of the chromatography column. The more soluble the compounds are in the stationary liquid, the more slowly the compounds pass through the column and so a separation is effected. |

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| **Question 19** (7 marks) |  | |
| This is an extended-response question and the task is a rather grandiose one – *evaluate the impact on society* ....      *Evaluate* means make a judgement: are the impacts large or small, good or bad? What are the impacts? And do this for two broad areas, medicine and industry.       The task is more easily done for medicine because we can summarise the impacts fairly concisely as (a) opening up a wide range of non-invasive diagnostic techniques and (b) providing effective treatments for many cancers. The impacts on industry are harder to summarise or evaluate because many industries have not been affected by radioisotopes at all (they do not use any) so we need to focus on particular industries.      Note that specific radioisotopes and their chemical properties are required.      The exam paper allows 20 lines for this answer, probably suggesting 150 to 200 words. The answer here is probably too long; two specific examples, one for medicine and one for industry would probably have sufficed. (p 86-8) | There have been significant beneficial impacts on society from the use of radioisotopes in both medicine and industry, first because radioisotopes have allowed many tasks to be done more efficiently or more accurately than before and secondly because they have allowed the introduction of procedures that would not otherwise have been possible. However there have also been some detrimental impacts in that radioisotopes have not always been handled as carefully or as safely as possible which has led on occasions to some harm to people and to the environment. Long-term storage of the low-level radioactive wastes from such usages is still an ongoing problem.      The beneficial impacts have been particularly great in medicine in that radioisotopes have led to new non-invasive diagnostic tests that otherwise would not have been possible. In addition radioisotopes have led to the introduction of effective radiation therapy for many cancers.      For radiation therapy cobalt-60 is often used. This is an  and  emitter with the  rays having sufficient energy to destroy cancer cells. Co-60 has a half life of about 5 years which makes it convenient to use as a radiation source.       Technetium-90*m* is a radioisotope that is widely used to diagnose problems with blood circulation. It is a  emitter with the  rays having just enough energy to emerge from the body for detection without causing too much harm; the half life is about 6 hours which means it does not last long enough in the body to cause damage.       Industrially radioisotopes have been used in thickness gauges (using strontium-90 a  ray emitter with a half life of many years), in examining welds and metal components in machinery to detect faults and fatigue cracks (using caesium-137 which is a  emitter with sufficient energy to penetrate thick metal components and a sufficiently long half life not to need too frequent replacement).       Caesium-137 is also to irradiate medical supplies (to sterilise them) and certain foodstuffs (to kill bacteria and so increase shelf life).      In industries where radioisotopes have been used they have had considerable beneficial impacts, though there are many industries where they have not been used and so have had no impact at all. | |
| **Question 20** (4 marks) |  |  |
| You need to know that the anode is the electrode where oxidation is occurring.      To get the overall reaction just add up the two given equations (since they already contain the same number of electrons). (p 58-9) | **(a)** | The anode is the plain lead plate at which the reaction that is occurring is Pb(*s*) + SO42–(*aq*)     PbSO4(*s*) + 2e–  Overall reaction: Pb(*s*) + PbO2(*s*) + 4H+(*aq*) + 2SO42–(*aq*)     2PbSO4(*s*) + 2H2O(*l*) |
| This is an unusual question; it does not refer specifically to any item in the syllabus document. You just have to use common sense to answer it. | **(b)** | One benefit is that the car owner gets better value both in money and energy terms from the battery. Considerable amounts of expensive materials such as lead, lead(IV) oxide, polystyrene (for the case) and sulfuric acid are used to make the battery and a lot of energy is involved in making or extracting these substances.       Although some materials from no-longer-useable batteries are reused, much is wasted. Hence the longer the battery lasts the greater the economic and environmental benefits to the car owner and society generally. |
| **Question 21** (5 marks) |  | |
| You are required to show your working for this question. (p 134, 151) | **(a)** | 0.005 mol/L sulfuric acid is sufficiently dilute for it to be completely dissociated: H2SO4     H+ + HSO4–     2H+ + SO42– Therefore concentration of H+ ions = 2 x 0.005 = 0.010 mol/L pH = –log10 (0.010) = 2.0 Hence the cabbage indicator would be **red**. |
| Having set out your working in detail in (a) a briefer account here is sufficient since it just follows from (a) | **(b)** | If 10 mL 0.005 mol/L sulfuric acid was diluted to 100 mL, the concentration of H2SO4 would be 0.0005 mol/L and so the concentration of H+ 0.0010 mol/L. pH would be 3.0 and so the indicator would be **violet**. |
| Set out your working so that the examiner can follow your reasoning. That way if you make a mistake you may get some marks whereas a wrong answer with no working will get zero marks.      Include a chemical equation to get the correct mole ratio. You could have used the equation H2SO4 + 2NaOH    Na2SO4 + 2H2O and based you calculation on that.      Watch the number of significant figures in your final answer. 0.005 has only one so your answer also must have only one. (p 160-1) | **(c)** | No of moles of H+ in 15 mL (= 0.015 L) = 0.015 x 2 x 0.0005                                                          = 1.5 x 10–5 Since the reaction is H+ + OH–    H2O No of moles of NaOH required = 1.5 x 10–5    Volume of 0.005 mol/L solution required  = 1.5 x 10–5 / 0.005                                                             = 0.003 L  = **3 mL** |

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| **Question 22** (7 marks) |  | |
| Again set out your calculation so the examiner can follow your reasoning. Note that it is ppm of sulfur, not sulfur dioxide in the diesel, so you need the molar mass of S (32.1) not of SO2. (p 128-9) | **(a)** | In November 2007 the concentration of sulfur in diesel fuel is 50 ppm, that is 50 g S in 106 g diesel. Mass of S in 60 kg (= 6.0 x 104 g)  =  6.0 x 104 x 50 / 106                                                    = 3.0 g Number of moles of S  = 3.0 / 32.1 = 0.0935 The chemical reaction is S(in fuel) + O2    SO2 so 1 mol S     1 mol SO2 Therefore number of moles of SO2 formed = 0.0935 At 25oC and 100 kPa volume = 0.0935 x 24.79 L                                            = **2.3 L** |
| *Evaluate the effect*: is it large or small, good or bad? You need to be aware that vehicles are not the major source of sulfur dioxide in the atmosphere, so reducing the sulfur content of diesel will not have a big effect on the concentration of sulfur dioxide in the atmosphere.      This is a chemistry exam, so bring chemistry into it wherever possible. Hence the inclusion of an equation for the formation of acid rain. (p 121-6) | **(b)** | The policy will have a small but significant beneficial effect upon the environment in that it will lead to some reduction in the concentration of sulfur dioxide in the atmosphere. Sulfur dioxide in the atmosphere is a pollutant because it is detrimental to the health of humans and other animals (unpleasant odour and causes respiratory problems) and it can inhibit growth and cause damage to plants and trees; it also causes acid rain which can damage buildings and harm fish in lakes. SO2(*g*) + H2O(rain drops)    H2SO3(*aq*) with H2SO3(*aq*) being easily oxidised to H2SO4(*aq*).      While the policy represents a big proportional reduction in the concentration of sulfur in diesel fuel, it has only a small effect on the overall concentration of sulfur dioxide in the atmosphere because (i) petrol not diesel is currently the major fuel for motorised transport and (ii) industry (particularly extraction of metals) and electricity generation (coal burning) not transport are generally the major sources of sulfur dioxide in the atmosphere.      However the policy will prevent emissions from diesel-fuelled vehicles becoming more of a problem as the proportion of vehicles using diesel increases as seems to be the current trend. |

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| **Question 23** (3 marks) | |  | |
| You need to know the conditions needed to bring about esterification – acid catalyst, high temperature, use of a reflux condenser. The marks available do not justify drawing a diagram of refluxing.      Strictly speaking the structural formula is the one given. However you would probably receive full marks had you given a condensed structural formula such as: http://www.cci.net.au/conqchem/Exam07HexanoateCond.gif However you should not abbreviate the ester group to –COO– as that does not show that you understand the true nature of that group. (p 173-6) | | A few drops of concentrated sulfuric acid are added as a catalyst. The reaction mixture is heated for about 20 to 40 minutes for reaction to occur (otherwise it is too slow). This heating should be done using a reflux condenser in order not to lose the volatile reactant (ethanol) or the ester product. http://www.cci.net.au/conqchem/Exam07Hexanoate.gif | |
| **Question 24** (5 marks) | |  |  |
| Calculate the molecular weights and write them beside the alkanols on the question paper, then plot the graph. methanol      32 ethanol         46 1-butanol      74 1-propanol    60      In drawing the graph use scales that use up as much of the grid provided as possible but still convenient to use; the ones used here are the most appropriate.      You do not have to decide whether to join the points with straight lines of whether to draw a line of best fit since the points lie virtually on a straight line.       The value for 1-propanol from the graph is 1360 kJ/mol, but is the answer 1360 or 1.36 x 103 or 1.4 x 103? The safest option is to follow the question and leave it as 1360, though in view of part (b) the data should probably be 0.5, 0.9 and 1.8 x 103 and the answer 1.4 x 103. | **(a)** | http://www.cci.net.au/conqchem/2007ExamGraphS.gif | |
| What does *theoretical value* mean? To a chemist it means the value calculated from some theory as opposed to a value measured experimentally. If this is so, then the reason for the difference is probably that the theory is not very accurate, particularly as the experimental values in the data are given to at least two if not three significant figures.     However bearing in mind the loose language that is often used in school laboratories when assessing student results, it may well mean the accurately-determined (or correct) experimental value. In that case the reason for the discrepancy is probably some deficiency in the experimental method used to obtain the heats of combustion given in the question. (p 36-7, exercise 39b on p 38) | | **(b)** | **(i)**  Heat of combustion of 1-propanol = **1360 kJ/mol**  **(ii)** A possible reason for the discrepancy is incomplete combustion in the measurement of the values given for the graph. If some of the alkanol had been converted to carbon monoxide instead of to carbon dioxide, then less energy (heat) would have been released in the experiments and so the values would be lower than if complete combustion had occurred. |
| **Question 25** ( 5 marks) | |  |  |
| *Assess the effectiveness* ... :is it effective or not? is it very effective or just moderately effective? What is it effective against? Then give your reasons for your assessment. *With reference to its chemical properties* means you must refer to its amphoteric or amphiprotic nature. And this is a chemistry exam so include at least two equations – for reaction with an acid and with an alkali.       You probably do need to say that part of its effectiveness is due to the fact that an excess of it will not hurt people or the environment. There are 5 marks for this question.       The last two equations are not really necessary but if you have time (and there are 9 minutes for this question), include them. (p 168, 154-5) | | Sodium hydrogen carbonate is very effective in neutralising chemical spills, because it is amphoteric (amphiprotic) which means that it can neutralise both acid and alkali spills. In addition if excess NaHCO3 is used (as is almost inevitable in cleaning up chemical spills), it is relatively harmless to people and the environment in that it is a neutral substance and is not in any way poisonous. Being amphoteric, NaHCO3 reacts with acids (H+ ions): NaHCO3(*s*) + H+(*aq*)    Na+(*aq*) + H2O(*l*) + CO2(*g*) and with alkalis (OH– ions): NaHCO3(*s*) + OH–(*aq*)    Na+(*aq*) + H2O(*l*) + CO32–(*aq*) In aqueous solution on its own (after it has neutralised any acid or alkali) the hydrogen carbonate ion hydrolyses as both an acid and a base: HCO3–(*aq*) + H2O(*l*)  http://www.cci.net.au/conqchem/revarrowLB.gif  H3O+(*aq*) + CO32–(*aq*) HCO3–(*aq*) + H2O(*l*)  http://www.cci.net.au/conqchem/revarrowLB.gif  H2CO3(*aq*) + OH–(*aq*) Hence the solution is approximately neutral and so does minimal damage to people and the environment. | |

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| **Question 26** ( 4 marks) | |  |
| You need to be able to draw the structures of polyethylene and polystyrene and know how chain stiffening and chain branching affect properties – and know some common products made from each polymer. A reasonable distribution of marks would be one each for the structures, one for the differences in properties and one for products formed from each. (p 13-21) | | Polyethylene has the structure: http://www.cci.net.au/conqchem/Polyeth.gif It can form a long chain as above but can also form as a branched chain molecule http://www.cci.net.au/conqchem/PolyethBranch.gif Both forms of polyethylene are relatively floppy molecules because of the smallness of the H atoms on the C–C–C chains. This causes polyethylene to be relatively soft and flexible, making it well suited for wrapping materials, disposable shopping bags, milk bottles, storage containers, simple household goods and soft toys.     Polystyrene has the structure: http://www.cci.net.au/conqchem/Polystyrene.gif where the hexagonal structure is the benzene ring, C6H5. This benzene ring is quite large – much larger than an H atom – and this makes the chain quite stiff (much less floppy – called chain stiffening) so polystyrene is quite a hard plastic. Also in contrast to polyethylene, there is very little chain branching in polystyrene. This means that the linear chains can pack together in an orderly way to make a crystalline substance. The hardness of polystyrene means that it is particularly useful for making car battery cases and screw-driver handles, and that hardness combined with the clarity that results from a crystalline structure makes it ideal for making modern furniture, CD cases and clear drink cups. |
| **Question 27** (8 marks) | |  |
| Give enough detail to convince the examiner you know how to do this experiment. Note that an equation is required. (p 220) | **(a)** | We would take a measured volume of water (by pipette) and slowly add silver nitrate solution to it from the burette with stirring. The reaction occurring is: AgNO3(*aq*) + Cl–(*aq*)     AgCl(*s*) + NO3–(*aq*) When it appeared that no more precipitate was forming we would test for completeness of precipitation. We would weigh the sintered glass crucible, then separate the precipitate from the solution by carefully pouring the mixture through the crucible. The vacuum pump would draw the solution through the sintered glass while the AgCl precipitate collected on it. We would wash the precipitate with a few mL water then with a few mL of ethanol (to facilitate drying) then dry the crucible and precipitate in a warm (not hot) oven. After cooling, the precipitate and crucible would be weighed and the weight of precipitate found by subtraction. From the mass of AgCl we would calculate the mass of chlorine in it and hence in the water sample being analysed and from the known volume of the water sample calculate the chloride ion concentration in the sample. |
| Show your working | **(b)** | Molar masses of Cl and AgCl are 35.5 and 143.4 g/mol Mass of Cl in the precipitate  =  3.65 x 35.5 / 143.4  g                                            =  0.904 g This is in 50 mL water. Assuming that this water has a density of 1.00 g/mL, we have                    0.904 g Cl in 50 g water Mass of Cl in 106 g water  =  0.904 x 106 / 50 g                                        =  1.81 x 104 g Concentration of chloride in this water is **1.81 x 104 ppm** |
| There are two parts to this: first chloride has a detrimental effect upon water quality and secondly chloride frequently does find its way into water supplies. (p 268-9) | **(c)** | If chloride is present in water in significant concentrations, say above a thousand ppm, it can have detrimental effects upon crops being irrigated with it and animals (including people) drinking it. Chloride frequently gets into water supplies either from seepage of sea water into underground fresh water aquifers or by water tables rising up through salty soils below the surface and entering fresh water streams and rivers. Because high chloride concentrations are a problem and because they can quite easily occur, it is necessary to regularly monitor chloride concentrations in water supplies. |