WESLEY COLLEGE

PART 1		50
PART 2		70
PART 3		80
TOTAL		200

YEAR 12 TRIAL EXAMINATIONS 9 OCTOBER 2012

CHEMISTRY

CANDIDATE'S NAME: …….

NAME OF YOUR TEACHER: …….

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten Minutes
Working time for paper: 3 Hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer Paper
Separate Chemistry Data Sheet

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser, correction fluid/tape, ruler, highlighters

Special Items: Non-programmable calculators satisfying the conditions set by the Curriculum Council for this course

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room. It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you hand it to the supervisor BEFORE reading any further.

STRUCTURE OF PAPER

Part	Format	No. of Questions Set	No. of Questions to be Attempted	Marks Allocated	Recommended Time (Approx) /Minutes
1	Multiple choice	25	ALL	50	45
2	Short answer	9	ALL	70	65
3	Extended answers	6	ALL	80	75

Total marks for paper = 200 (100%)

INSTRUCTIONS TO CANDIDATES

Reading Time: The examiners recommend that candidates spend the reading time mainly reading the Instructions to Candidates and Parts 2, 3 and 4

Part 1 – Multiple Choice
Answer ALL questions in Part 1 on the Multiple Choice Answer Sheet by placing a CROSS using a pen in the appropriate box.

If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will **not** be deducted for incorrect answers. If you need to make a correction make sure your intent is clear. No marks will be awarded if the intent of your answer is not certain.

FEEL FREE TO WRITE OR DO WORKING ON THE QUESTION PAPER; many students who score high marks on the Multiple Choice Section do this.

Parts 2 and 3. Write your answers in this Question/Answer Booklet.
When calculating numerical answers, show your reasoning clearly unless instructed otherwise.

Spare pages are included at the end of the paper. They can be used for planning your responses and/or as additional space if required to continue an answer.

CHEMICAL EQUATIONS

For full marks, chemical equations should refer only to those specific species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^{+}_{(aq)}$], **molecules** [for example $NH_{3(g)}$, $CH_3COOH_{(l)}$, $CH_3COOH_{(aq)}$] or **solids** [for example $BaSO_{4(s)}$, $Cu_{(s)}$, $Na_2CO_{3(s)}$].

SEE NEXT PAGE

PART 1: MULTIPLE CHOICE ANSWER SHEET

YOUR NAME: ……..

INSTRUCTIONS: Using a pen mark your selections on this sheet by using a X. If you need to make a correction make sure you intent is clear.

You may choose to carefully remove this answer sheet

1. [A] [B] [C] [D]
2. [A] [B] [C] [D]
3. [A] [B] [C] [D]
4. [A] [B] [C] [D]
5. [A] [B] [C] [D]
6. [A] [B] [C] [D]
7. [A] [B] [C] [D]
8. [A] [B] [C] [D]
9. [A] [B] [C] [D]
10. [A] [B] [C] [D]
11. [A] [B] [C] [D]
12. [A] [B] [C] [D]
13. [A] [B] [C] [D]
14. [A] [B] [C] [D]
15. [A] [B] [C] [D]
16. [A] [B] [C] [D]
17. [A] [B] [C] [D]
18. [A] [B] [C] [D]
19. [A] [B] [C] [D]
20. [A] [B] [C] [D]
21. [A] [B] [C] [D]
22. [A] [B] [C] [D]
23. [A] [B] [C] [D]
24. [A] [B] [C] [D]
25. [A] [B] [C] [D]

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PART 1 (50 marks = 25% of paper)

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet.

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1. Which of the following statements is **true** about the trends in the periodic table?

   (a) The melting points of group 17 elements are greater at the top of the group than at the bottom.
   (b) Elements on the left hand side of the table are less electronegative than elements on the right.
   (c) Both the first ionisation energy and the radius of elements in group 1 increase from the top of the group to the bottom.
   (d) Both the first ionisation energy and the radius of elements in period 3 decrease from left to right across the period.

2. The molar heat of sublimation (the amount of energy required to convert 1 mole of solid directly to the gas state at its melting point) of helium is 0.105 kJ mol^{-1}, whereas that of ice is 46.9 kJ mol^{-1}. Which of the following statements help to explain this difference?

   (i) Only dispersion forces are present between helium atoms.
   (ii) There are stronger forces between water molecules in ice.
   (iii) There are strong covalent bonds within water molecules in ice.
   (iv) There are weak covalent bonds between helium atoms.

   (a) (i) and (ii) only.
   (b) (i), (ii) and (iii) only.
   (c) (i), (iii) and (iv) only.
   (d) (i), (ii), (iii) and (iv).

3. Which of the following represents the correct shapes of each of the molecules $NC\ell_3$, CO_2, SO_2 and CH_2O respectively as shown?

	$NC\ell_3$	**CO_2**	**SO_2**	**CH_2O**
(a)	pyramidal	linear	bent	triangular planar
(b)	pyramidal	bent	bent	pyramidal
(c)	triangular planar	bent	linear	pyramidal
(d)	triangular planar	linear	linear	triangular planar

SEE NEXT PAGE

4. Chlorine has two naturally occurring isotopes, $^{35}C\ell$ and $^{37}C\ell$. $^{35}C\ell$ is approximately three times more abundant than $^{37}C\ell$. Which of the following statements is **false**?

   (a) 1L samples of $^{35}C\ell_2$ and $^{37}C\ell_2$ at the same temperature and pressure will contain the same number of molecules.
   (b) The average relative molecular mass of a chlorine molecule will be closer to 70 than it is to 74.
   (c) Sodium metal will react more violently when placed in gas jar of $^{35}C\ell_2$ than it will when placed in a gas jar of $^{37}C\ell_2$.
   (d) $^{37}C\ell_2$ has a slightly higher boiling point than $^{35}C\ell_2$

5. Which of the following best explains why calcium sulfate is virtually insoluble in ethanol?

   (a) There are no forces that can form between the ions of calcium sulfate and the molecules of ethanol.
   (b) Although ethanol is a polar molecule, it is not able to form ion-dipole forces.
   (c) The calcium and sulfate ions do not form sufficiently strong ion-dipole forces with ethanol molecules to disrupt the calcium sulfate crystal lattice.
   (d) The hydrogen bonds between ethanol molecules are strong.

6. Two atoms X and Y have electron configurations shown below.

   X : 2,8,4 Y : 2,8,7

   Which one of the following formulae best describes the product when X and Y combine?

   (a) Covalent, with the formula XY_4
   (b) Covalent, with the formula X_2Y_5
   (c) Ionic, with formula XY_2
   (d) Ionic, with formula X_2Y_5

7. In which of the following would particles have the highest average velocity at standard temperature and pressure?

   (a) Carbon monoxide
   (b) Ethane
   (c) Hydrogen fluoride
   (d) Nitrogen

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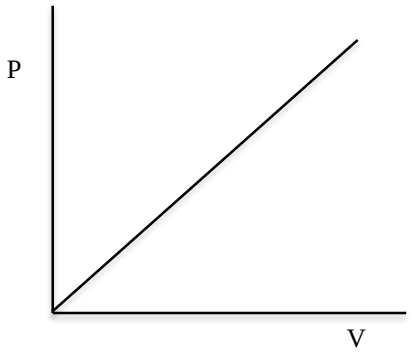
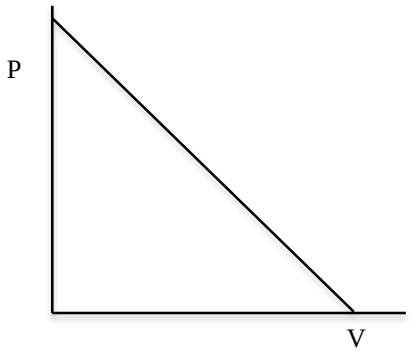
8. Which of the graphs below best represents the relationship between the pressure and volume of a gas at constant temperature?

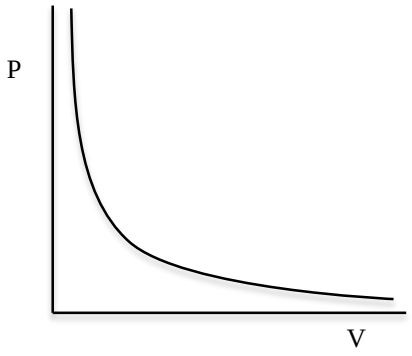
(a)



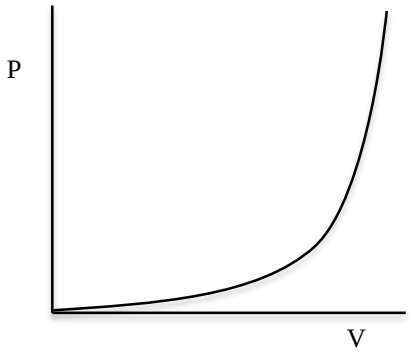
(b)



(c)



(d)



9. Consider the equilibrium represented in the following equation. The colour of each species is indicated below its formula.

$$\underset{\text{BLUE}}{Cu^{2+}(aq)} + \underset{\text{COLOURLESS}}{4C\ell^{-}(aq)} \rightleftharpoons \underset{\text{GREEN}}{[CuC\ell_4]^{2-}(aq)}$$

Which of the following statements is correct?

(a) At equilibrium the Cu^{2+} is no longer reacting with $C\ell^{-}$.
(b) Adding concentrated hydrochloric acid causes the blue colour to intensify.
(c) When the system reaches equilibrium, the concentrations of reactants and products are equal.
(d) Adding some silver nitrate will cause the blue colour to intensify.

SEE NEXT PAGE

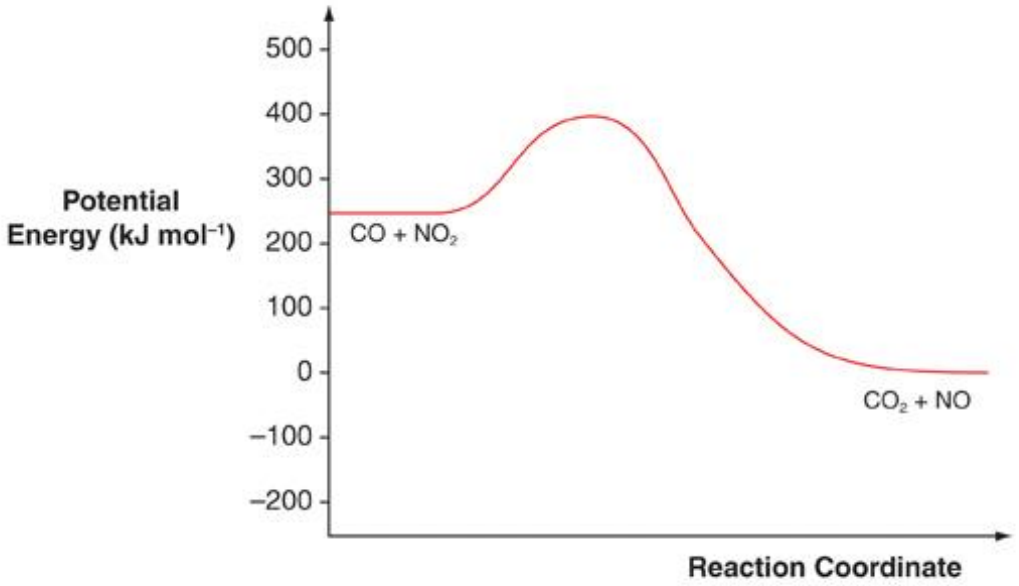
10. In the following reaction, energy is released as the reactants turn to products.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

If the temperature of an equilibrium mixture of N_2, H_2 and NH_3 were increased, what would happen to the mass of NH_3 and the equilibrium constant, K?

	Mass of NH_3	**Equilibrium constant**
(a)	Increase	Increase
(b)	Increase	Decrease
(c)	Decrease	Increase
(d)	Decrease	Decrease

11. Carefully consider the following diagram:



For the following reaction, choose the correct values for the enthalpy change and the activation energy.

$$CO_2 + NO \rightarrow CO + NO_2$$

	Enthalpy change in kJ mol^{-1}	**Activation Energy in kJ mol^{-1}**
(a)	-400	-150
(b)	+150	-400
(c)	-400	+250
(d)	+250	+400

SEE NEXT PAGE

12. Which one of the following equations shows the reacting species only? (i.e. those actually consumed in the reaction)

(a) $CH_3COOH(aq) + Ba(OH)_2(aq) \rightarrow Ba(CH_3COO)_2(aq) + H_2O(l)$

(b) $Mg(s) + O_2(g) \rightarrow MgO(s)$

(c) $CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(l) + CO_2(g)$

(d) $Ca(OH)_2(aq) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + H_2O(l)$

13. A vessel is filled with 10 g of sulfur dioxide at 100°C. The vessel is evacuated, and filled with 5 g of another gas at the same temperature. Given that the new gas exerts twice as much pressure, what could the new gas be?

(a) Methane
(b) Oxygen
(c) Carbon dioxide
(d) Cyclohexane

14. What is the conjugate acid of the hydrogensulfate ion?

(a) HSO_4^-
(b) H_2SO_4
(c) SO_4^{2-}
(d) H_2S

15. The equilibrium constant for pure water is measured to be 5.13×10^{-13} at 100°C. Which of the following is correct?

(a) The concentration of H^+ ions is 7.16×10^{-7} mol L^{-1} and the water is acidic.
(b) The concentration of H^+ ions is 7.16×10^{-7} mol L^{-1} and the water is neutral.
(c) The concentration of OH^- ions is 7.16×10^{-7} mol L^{-1} and the water is basic.
(d) The concentration of OH^- ions is 7.16×10^{-7} mol L^{-1} and the water is acidic.

SEE NEXT PAGE

Questions 16, 17 and 18 relate the following information:

Rossco was asked to determine the concentration of a solution of ethanoic acid that had a concentration of approximately 4.0×10^{-1} mol L^{-1}. He pipetted 20.0 mL of a 0.500 mol L^{-1} solution of sodium hydroxide into a flask and titrated the ethanoic acid against this sodium hydroxide solution, using phenolphthalein as the indicator.

16. What would be the pH of the sodium hydroxide solution at the start of the titration?

(a) 13.7

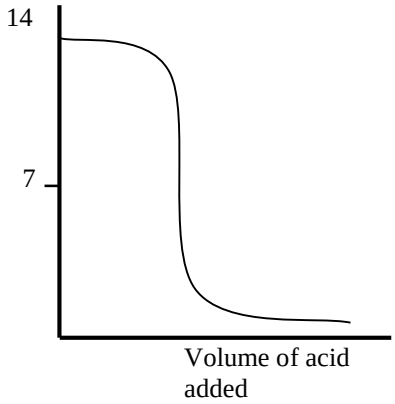
(b) 7.0

(c) 14.0

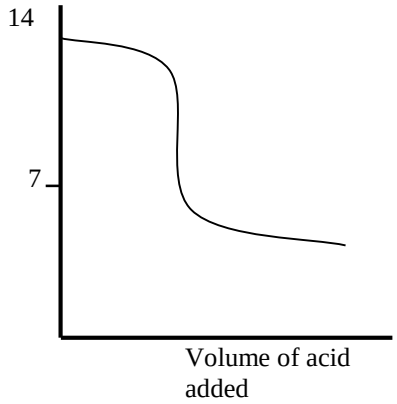
(d) 12.7

17. If the ethanoic acid was added until it was slightly in excess, which of the following pH graphs would show the variation of pH during the titration?

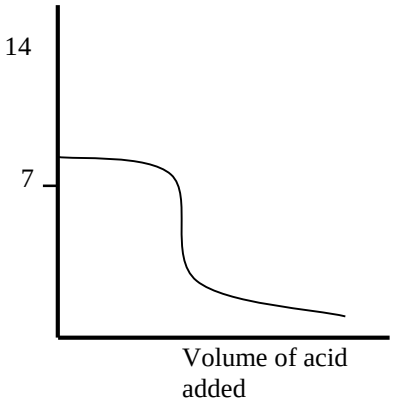
(a)



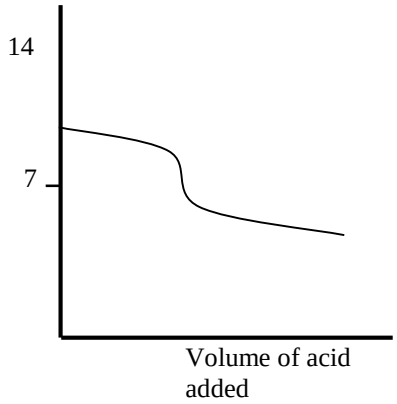
(b)



(c)



(d)



18. What approximate volume of ethanoic acid would she expect to have added at the end point of the titration?

(a) 20 mL

(b) 30 mL

(c) 25 mL

(d) 35 mL

SEE NEXT PAGE

19. 25 mL of a 0.010 mol L^{-1} solution of barium hydroxide, $Ba(OH)_2$, is diluted by adding 225 mL of water at 25°C. What would be the pH of the resulting solution?

(a) 2.00
(b) 2.70
(c) 11.00
(d) 11.30

20. In which of the following equations is water acting as a Brønsted-Lowry base?

(a) $2H_2O + Na \rightarrow 2NaOH + H_2$
(b) $[Fe(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Fe(OH)(H_2O)_5]^{2+} + H_3O^+$
(c) $H_2O + NH_3 \rightleftharpoons NH_4^+ + OH^-$
(d) $HPO_4^{2-} + H_2O \rightleftharpoons OH^- + H_2PO_4^-$

21. Which of the following will be oxidised by liquid Br_2 ?

(a) Au(s)
(b) $C\ell^-$ in a solution of $KC\ell$
(c) Fe^{3+} in a solution of $Fe(CH_3COO)_3$
(d) H_2S in acidified aqueous solution

22. Despite having been invented in 1859, lead-acid batteries are still used in many vehicles. The overall equation for the reaction taking place when a lead-acid battery <u>discharges</u> is:

$$Pb + PbO_2 + 2HSO_4^- + 2H^+ \rightarrow 2PbSO_4 + 2H_2O$$

Which of the following represents the half-cell reaction at the positive electrode of the battery?

(a) $Pb + HSO_4^- \rightarrow PbSO_4 + H^+ + 2e^-$
(b) $PbSO_4 + H^+ + 2e^- \rightarrow Pb + HSO_4^-$
(c) $PbO_2 + H_2SO_4 + 2H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$
(d) $PbSO_4 + 2H_2O \rightarrow PbO_2 + HSO_4^- + 3H^+ + 2e^-$

23. Which of the following molecules is not an isomer of the others?

(a) 2-methylhex-3-ene

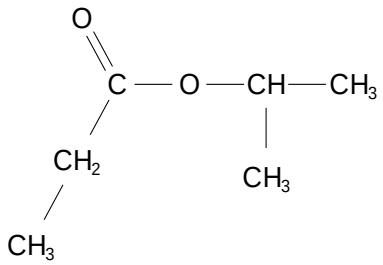
(b) 1,3-dimethylcyclopentane

(c) 2,3-dimethylpent-1-ene

(d) ethylpentane

SEE NEXT PAGE

24. Which of the pairs of compounds below could be used to make the following molecule?



(a) Propanoic acid and propan-2-ol

(b) Propanoic acid and 2-methylpropanol

(c) Ethanoic acid and propan-2-ol

(d) Ethanoic acid and propan-1-ol

25. Corrosion is a redox process. Which one of the following explains why coating iron with nickel protects the iron from corrosion?

(a) Nickel accepts electrons from iron.
(b) Iron and nickel form an alloy that is particularly resistant to redox processes.
(c) Nickel is a stronger oxidising agent than iron.
(d) The thin coating of nickel prevents iron from reacting.

END OF PART 1

SEE NEXT PAGE

PART 2 Short Answer (70 marks)

This part contains **nine (9)** questions. Answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

Suggested working time: 60 minutes.

Question 1 **[12 marks]**

Write ionic equations and observations for any reactions that occur in the following procedures. In each case describe in full what you would observe, including any

- colours
- odours
- precipitates (state the colour)
- gases evolved (state the colour or describe as colourless).

If no change is observed, you should write "no visible change".

(a) Copper(II) nitrate solution is added to excess sodium carbonate solution.

Equation **(2 marks)**

Observation **(1 mark)**

(b) A colourless organic liquid methylpropan-2-ol is added to a dilute acidified solution of potassium dichromate.

Equation **(2 marks)**

Observation **(1 mark)**

SEE NEXT PAGE

(c) Sodium metal is added to pure acetic acid (ethanoic acid).

Equation **(2 marks)**

_____

Observation **(1 mark)**

_____

_____

_____

(d) An acidified potassium dichromate solution is reacted with oxalic acid ($H_2C_2O_4$) to produce chromium (III) ions, carbon dioxide and water.

Equation **(2 marks)**

_____

Observation **(1 mark)**

_____

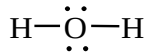
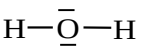
_____

_____

SEE NEXT PAGE

Question 2 **(9 marks)**

For each species listed in the table below, draw the Lewis structure, representing all valence shell electron pairs either as : or as — **and** state or sketch the shape of the species **and** state the polarity of the molecule.

(for example, water  or  or  bent, polar)

Species	Structure (showing all valence electrons)	Name of shape	Polarity of molecule (polar or non-polar)
Hydrogen cyanide HCN			
Difluoromethane CH_2F_2			
Sulfur trioxide SO_3			

SEE NEXT PAGE

Question 3 **(5 marks)**

Trichloroethanoic acid ($CC\ell_3COOH$) is a weak acid that is sometimes used in the removal of warts and tattoos. It allows new skin cells to appear by removing the first few layers of skin. The sodium salt of the acid (sodium trichloroethanoate) is also used as a weedkiller.

(a) Write an equation to show the reaction that takes place when trichloroacetic acid is dissolved in water. (1 mark)

_____

(b) State and explain –using your equation above, what would happen to the pH (increase, decrease, or no change) of a 1 mol L^{-1} trichloroethanoic acid solution if it were mixed with a solution of sodium trichloroethanoate. (4 marks)

Effect on pH (circle one) Increases Decreases No change

Reason

_____

_____

_____

_____

_____

Question 4 **(5 marks)**

Give the name (or formula) of the species that match each of the following descriptions.

i. The conjugate base of carbonic acid. _____ (1 mark)

ii. A tertiary alcohol with 4 carbon atoms. _____ (1 mark)

iii. A diatomic element with a triple bond. _____ (1 mark)

iv. A covalent network compound. _____ (1 mark)

v. A polar oxide of carbon. _____ (1 mark)

SEE NEXT PAGE

Question 5 **(10 marks)**

Wines often contain a small amount of sulfur dioxide that is added as a preservative. The amount of sulfur dioxide added needs to be carefully calculated; too little and the wine goes bad; too much and the wine tastes of sulfur dioxide. Edward and Anthony are investigating this problem.

The sulfur dioxide content of a wine can be found by titrating the wine with aqueous iodine solution. In this reaction the sulfur dioxide, $SO_2(aq)$, is converted to sulfate ions and the iodine, $I_2(aq)$, to iodide ions.

(a) Using the information above determine the two half-equations and overall equation for the reaction taking place in acidic conditions. (4 marks)

(b) State, with a reason, whether sulfur dioxide is oxidised or reduced in this reaction (1 mark)

(b) The sulfur dioxide content of a wine can be found by titration. Anthony finds that the sulfur dioxide in 50.0 mL of white wine reacted with exactly 16.4 mL of 0.0100 mol L^{-1} aqueous iodine.

(i) Suggest a suitable indicator to use in this titration (1 mark)

(ii) Calculate the concentration of sulfur dioxide in the wine in grams per litre

(3 marks)

SEE NEXT PAGE

(a) The generally accepted maximum concentration of sulfur dioxide in wine is 0.25 g L^{-1}.

A concentration of less than 0.01 g L^{-1} is insufficient to preserve the wine.
Comment on the effectiveness of the sulfur dioxide in the wine analysed in (b). (1 mark)

Question 6 **[5 marks]**

Arrange the following compounds (all of similar molecular weight) in order of decreasing boiling point. In the table write "1" for the compound with the highest boiling point, down to "5" for the compound with the lowest boiling point.

Compound	**Boiling points in order (1=highest, 5=lowest)**
$CH_3CH_2CH_2CH_2CH_3$	
$CH_3CH_2CH_2CH_2COOH$	
$CH_3CH_2CH(CH_3)_2$	
$CH_3CH_2CH_2CH_2CH_2OH$	
$CH_3CH_2CH_2CH_2CHO$	

Question 7 **(4 marks)**

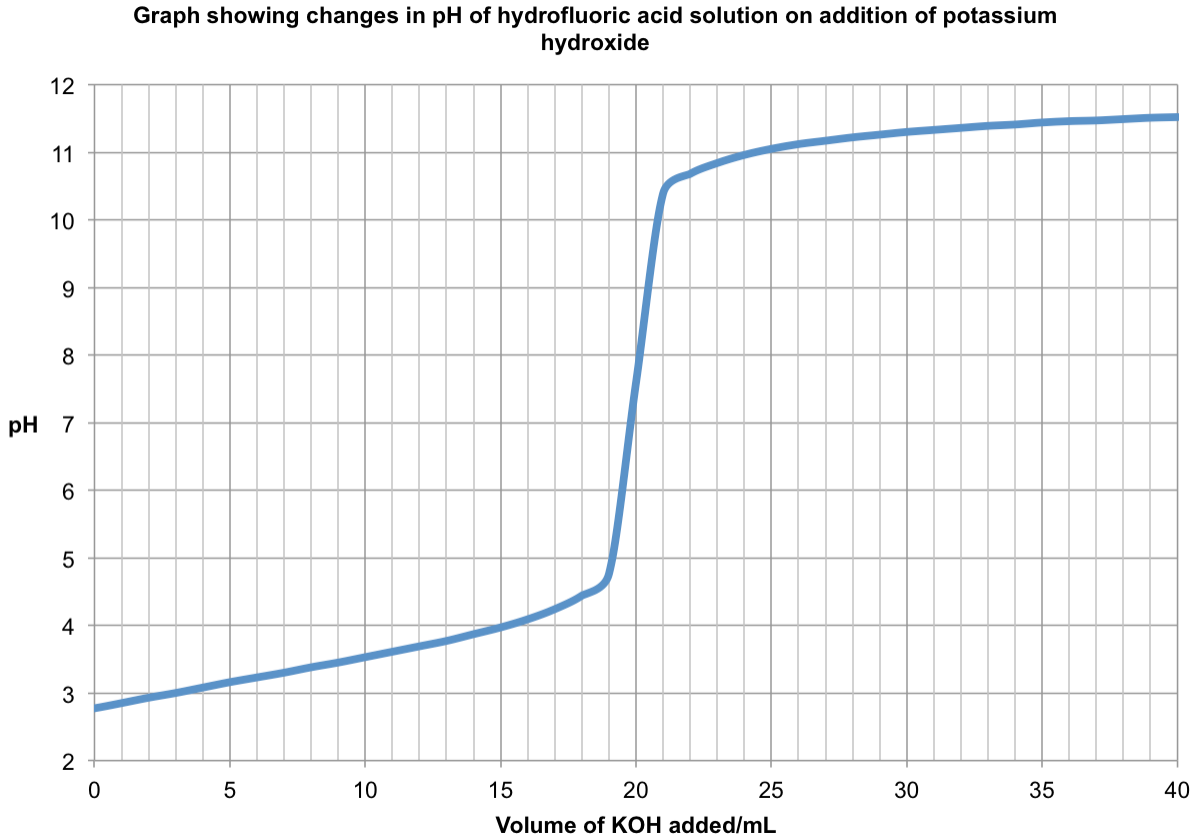
Give the IUPAC name of the following compounds.

Formula	**Name**
$CH_3(CH_2)_5CH(OH)CH_3$	
$CH_3CH_2COOCH_2CH_3$	
$CH_3CH_2COCH_2CH_3$	
$CH_3CH_2CH_2CHO$	

SEE NEXT PAGE

Question 8 **(9 marks)**

0.0100 mol L^{-1} potassium hydroxide was placed in a burette, and titrated against 20.0 mL aliquots of 0.0100 mol L^{-1} hydrofluoric acid. The pH of the solution was measured using a pH probe after the addition of each 1.00 mL of potassium hydroxide until 40.0 mL had been added. The results of the experiment are shown in the graph below:



The measured pH at the start of the experiment was 2.77.

(a) Using the given concentration of HF and the initial pH, determine the percentage of HF molecules which have been ionised (2 marks)

(b) Explain why the pH at the equivalence point was not 7. (3 marks)

SEE NEXT PAGE

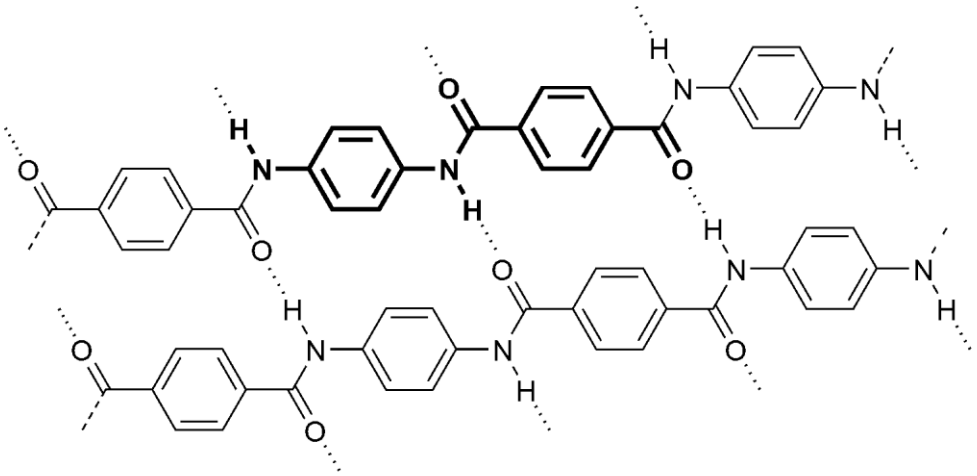
In a similar experiment to determine the concentration of ethanoic acid in a vinegar solution, a 5.00 mL sample of vinegar was diluted to 250 mL by adding water in a volumetric flask. 20.00 mL aliquots of this solution were then titrated against the same solution of potassium hydroxide but this time using an indicator instead of the pH probe.

(c) From a choice of phenolphthalein or methyl orange which indicator would you use and explain the effect on the calculated value of the acid concentration if you use the '<u>wrong</u>' indicator

(4 marks)

Question 9 **(11 marks)**

Kevlar is a synthetic fibre used in windsurfing sails and bulletproof vests. Like Nylon and Rayon, it is a condensation polymer, but its breaking strength is around ten times that of Nylon. The structure of Kevlar is shown below, with its repeating unit in bold.



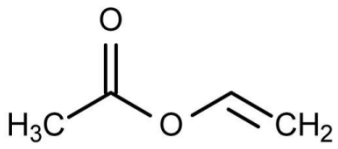
(a) Draw the structure of the two monomers that could be used to make Kevlar.

(2 marks)

Monomer 1	Monomer 2

SEE NEXT PAGE

Polyvinylacetate is a different polymer built up using the monomer vinyl acetate, whose formula is $CH_3COOCHCH_2$, and whose skeletal formula is shown below.



(b) In the space below, draw the structure of a length of polyvinyl acetate that would form from three vinyl acetate molecules. (2 marks)

Polyvinyl acetate can be dissolved in methanol to form polyvinyl alcohol (PVA).

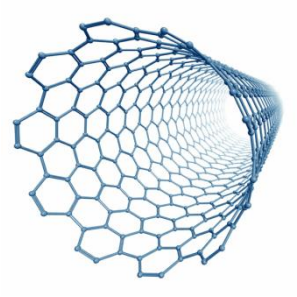
(c) Use your knowledge of intermolecular forces to explain why polyvinyl acetate is soluble in methanol. You may use a diagram to aid your explanation. (2 marks)

SEE NEXT PAGE

(d) The monomer unit, vinyl acetate, being an ester can also be hydrolysed in alkaline conditions to form two products. Write the equation for this reaction.

(2 marks)

Early in 2012, chemists working at Hanyang University in Korea were able to synthesise the toughest polymer yarn known at the time by mixing PVA with carbon nanotubes (CNTs) during the spinning of the yarns. One type of fibre, which was manufactured using PVA (polyvinyl alcohol) and single-walled carbon nanotubes (SWCNTs), had a toughness of 870 J/g, making it far stronger than spider silk (165 J/g) and more than ten times as strong as Kevlar (78 J/g).



Carbon nanotubes are an allotrope of carbon whose structure is shown in the picture, and is similar to that of graphite. They were discovered in 1991 as a spin-off from research into Buckminsterfullerenes, and have since found uses in a huge variety of applications, from medicine to electronics and molecular manufacturing.

(e) With reference to the structure and bonding present, explain whether or not you would expect carbon nanotubes to be able to conduct electricity. (3 marks)

End of Part 2

SEE NEXT PAGE

PART 3: Extended answer **40% (80 Marks)**

This part contains **six (6)** questions. You must answer **all** questions. Write your answers in the spaces provided.
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 65 minutes.

Question 1 **[10 marks]**

The Haber process for the manufacture of ammonia is operated by passing a mixture of nitrogen and hydrogen over finely divided iron at a pressure of 300 atm and a temperature of 450 °C.
The reaction is exothermic.

(a) (i) Write a balanced chemical equation for the reversible reaction between nitrogen and hydrogen. (2 marks)

_____

(ii) What is the purpose of the iron? (1 marks)

_____

_____

(b) Referring to Le Chatelier's principle explain why using high pressures are used. (3 marks)

_____

_____

_____

_____

_____

_____

(c) Even higher pressure would be more advantageous, however, in practice they are not used. Why is that? (1 mark)

_____

_____

SEE NEXT PAGE

(d) A temperature much higher than 450°C could also be considered. Explain one advantage and one disadvantage of using a higher temperature. (3 marks)

_____

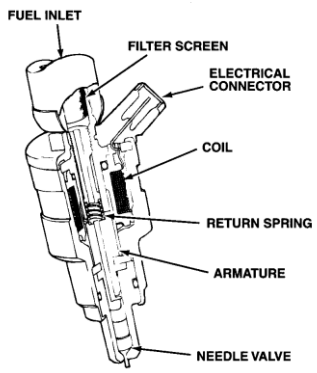
_____

_____

_____

Question 2 **(19 marks)**

The diagram shows a fuel injector of the type used in many combustion engines. The engine management system causes the needle valve to open and then close, ensuring that a precise amount of fuel enters the cylinder. The fuel enters the cylinder as a fine mist, and mixes with air. The cylinder then compresses the fuel-air mixture to around one tenth of its original volume



Modern combustion engines running on unleaded petrol use fuel composed mainly of octane and isomers of octane such as 2,2,4-trimethylpentane.. The research octane number (RON) gives an indication as to the composition of the mixture

(a) Write a balanced equation for the complete combustion of octane, C_8H_{18} (2 marks)

_____

(b) Using collision theory, explain the effect on the rate of the combustion reaction of the following reaction conditions.

i. Injecting the fuel as a fine mist. (2 marks)

_____

_____

ii. Compressing the air-fuel mixture prior to ignition. (2 marks)

_____

_____

SEE NEXT PAGE

(c) At a normal engine operating temperature of 1000°C, an injector injects 1.00 g of fuel for every 60.0 litres of air entering the cylinder at atmospheric pressure. Assuming all the components of the fuel have the molecular formula C_8H_{18}, and that air is exactly 20% oxygen by volume, find the limiting reagent.

(5 marks)

(d) Calculate the mass of any unused reactant from the above reaction mixture. (3 marks)

Since regulations governing emissions from motor vehicles have become stricter, fuel injection technology is found on most newly manufactured vehicles, owing to the fact that it significantly reduces the occurrence of <u>incomplete</u> combustion.

(e) With reference to the products of the reaction, explain why it is important to prevent this reaction occurring.

(2 marks)

SEE NEXT PAGE

As concern over the effect of burning fossil fuels mounts, alternatives are being sought to the internal combustion engine.

The photograph shows a proton exchange membrane (PEM) fuel cell, capable of offering outputs of up to 250 kW. Whilst not as efficient as some other designs of fuel cell, this type of cell offers the advantage that it runs at low temperatures and consists of a solid, flexible electrolyte that will not leak. As a result, this type of fuel cell is particularly well suited to use in automotive applications. The cell uses hydrogen as its fuel, which is combined with oxygen to produce water.

(f) State the cell voltage that can be obtained from a single fuel cell such as this. (1 mark)

(g) State TWO environmental advantages of the use of fuel cells to power motor vehicles, compared to combustion engines. (2 marks)

Question 3 **(18 marks)**

Kaleb conducted a series of experiments to investigate the physical and chemical properties of basic solutions. In the first experiment, he made a solution by dissolving 10.0 g of barium hydroxide in 250 mL of water.

(a) Calculate the pH of this solution. (5 marks)

(b) During the first experiment excess sulfuric acid was slowly added to the barium hydroxide solution and the electrical conductivity of the solution was measured. Kaleb observed the measurements were high at the start of the experiment, gradually fell to almost zero and then increased again.
Explain these observations. (4 marks)

Wanting to carry out experiments on basic solutions found outside of the laboratory, Kaleb decided to investigate milk of magnesia. Reading the information on the label, he realised that this was a saturated solution of magnesium hydroxide in water. The mixture gets its name from the fact that undissolved solid is suspended in the liquid, giving it a milky appearance.

In the mixture, the following reaction takes place:

$$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$$

(c) Write an expression for the equilibrium constant, K, for the above reaction. (1 mark)

(d) Explain whether you would you expect the value of K to be greater than one (> 1) or less than one (< 1). (2 marks)

SEE NEXT PAGE

Kaleb then wished to investigate whether the mass of solid present in the mixture could be affected by various changes. The mixture was divided equally into three beakers, and Kaleb carefully filtered the mixtures after each experiment to find the mass of undissolved magnesium hydroxide. One beaker was left unchanged to act as a control.

(e) For each of the changes described below, predict and explain what effect the change would have on the mass of solid present once the system had returned to equilibrium.

i. Distilled water was added to the mixture. (3 marks)

Effect on mass of solid (circle one)	INCREASE	DECREASE	NO CHANGE

Explanation

ii. A few drops of vinegar were added to the mixture. (3 marks)

Effect on mass of solid (circle one)	INCREASE	DECREASE	NO CHANGE

Explanation

SEE NEXT PAGE

Question 4 **(11 marks)**

In order to find the formula of hydrated copper(II) sulfate, $CuSO_4.nH_2O$, 5.02 g of the hydrated sulfate was dissolved in water, and the solution made up to 100 mL. To this solution was added excess potassium iodide, forming iodine according to the following equation:

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

10.0 mL portions of the resulting solution containing iodine were titrated using 0.100 mol L^{-1} sodium thiosulfate solution ($Na_2S_2O_3$), 20.02 mL being required for complete reaction. In this titration, thiosulfate ions reduce iodine to iodide, and are themselves converted to tetrathionate ions ($S_4O_6^{2-}$).

(a) Write ionic half-equations for this iodine/thiosulfate reaction to show the reduction and oxidation processes taking place.

(2 marks)

Reduction	
Oxidation	

(b) Write an overall ionic equation to show the reaction between thiosulfate ions and iodine.

(1 mark)

(c) Calculate the number of moles of copper ions in the original 5.02 g sample of hydrated copper(II) sulfate. (4 marks)

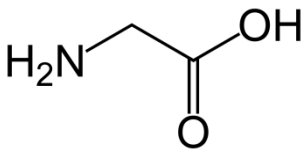
SEE NEXT PAGE

(d) Find the value of *n* in the formula of this hydrated sulfate and write its correct formula.
(4 marks)

Question 5 **(16 marks)**

Amino acids are the building blocks of proteins in biological systems, as well as playing important roles as intermediates in metabolism. There are 20 naturally occurring amino acids found in proteins. Ten of these are produced within the human body. The other ten, known as *essential* amino acids, must be obtained from food. Failure to obtain sufficient quantities of these can lead to degradation of the body's proteins. Since the body cannot store amino acids, it is therefore important that these *essential* amino acids are in food every day.

The simplest amino acid found in proteins is known as glycine. The skeletal formula of glycine is shown below.



In neutral solutions, glycine is found in a *zwitterion* form. Solutions of this ion can act as buffers.

(a) Draw the structure of the zwitterion ion for glycine in the space below. (1 mark)

(b) Briefly explain what buffer solutions can do and then use equations to explain how glycine in its *zwitterion* form is able to act as a buffer.

(4 marks)

Lysine is one of the ten *essential* amino acids. Elemental analysis shows that it is composed of the elements nitrogen, hydrogen, carbon, and oxygen. In an experiment to find its empirical formula, 2.175 g of lysine was combusted, producing 3.93 g of carbon dioxide and 1.87 g of water vapour. In a separate experiment, 1.986 g of lysine was reacted to turn all the nitrogen present into ammonia. It was found that 0.462 g of ammonia was formed.

(c) Determine the empirical formula of lysine. (7 marks)

SEE NEXT PAGE

SEE NEXT PAGE

Another sample of lysine, weighing 2.58 g, was heated in the absence of air. It was found that the vapour occupied a volume of 549 mL at 100°C and 100 kPa.

(d) Find the molecular formula of lysine (4 marks)

SEE NEXT PAGE

Question 6 **[6 marks]**

The amount of iron, as Fe^{2+}, present in a multivitamin tablet may be determined by titrating against potassium permanganate, $KMnO_4$. In one determination, two tablets were dissolved in 20.00 mL of distilled water in a conical flask. This required 15.85 mL of 0.002500 mol L^{-1} $KMnO_4$ to reach the equivalence point.

(a) Write the balanced equation for this reaction. (2 marks)

(b) Calculate the mass of iron, as Fe^{2+}, in milligrams in one multivitamin tablet? (4 marks)

END OF PART 3

Additional Working Space

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Additional Working Space

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