VCE CHEMISTRY 2015

YEAR 12 **TRIAL** EXAM

Units 3/4
Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	7	59	103
			Total 133

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STUDENT NUMBER

									Letter
Figures									
Words									

Student Name.....…….....

VCE Chemistry 2015 Year 12 Trial Exam Units 3/4

Student Answer Sheet

Instructions for completing test. Use only a 2B pencil. If you make a mistake, erase it and enter the correct answer. Marks will not be deducted for incorrect answers.

Write your answers to the Short Answer Section in the space provided directly below the question. There are **30 Multiple Choice** questions to be answered by circling the correct letter in the table below.

Question 1	A	B	C	D	*Question 2*	A	B	C	D
Question 3	A	B	C	D	*Question 4*	A	B	C	D
Question 5	A	B	C	D	*Question 6*	A	B	C	D
Question 7	A	B	C	D	*Question 8*	A	B	C	D
Question 9	A	B	C	D	*Question 10*	A	B	C	D
Question 11	A	B	C	D	*Question 12*	A	B	C	D
Question 13	A	B	C	D	*Question 14*	A	B	C	D
Question 15	A	B	C	D	*Question 16*	A	B	C	D
Question 17	A	B	C	D	*Question 18*	A	B	C	D
Question 19	A	B	C	D	*Question 20*	A	B	C	D
Question 21	A	B	C	D	*Question 22*	A	B	C	D
Question 23	A	B	C	D	*Question 24*	A	B	C	D
Question 25	A	B	C	D	*Question 26*	A	B	C	D
Question 27	A	B	C	D	*Question 28*	A	B	C	D
Question 29	A	B	C	D	*Question 30*	A	B	C	D

VCE Chemistry 2015 Year 12 Trial Exam Units 3/4

SECTION A – Multiple Choice Questions

Section A consists of 30 multiple-choice questions.
Section A is worth approximately 22 per cent of the marks available.
*Choose the response that is **correct** or **best answers** the question.*
A correct answer scores 1, an incorrect answer scores 0.
No mark is awarded if more than one answer is supplied for a question.
Indicate your choice on the answer sheet provided.

Question 1
Lactic acid and benzoic acids are both weak monoprotic acids.
Which of the following statements relating to aqueous solutions of these acids at 25°C is correct?

A. Diluting aqueous solutions of the acids increases both the number of H_3O^+ ions present and the pH.
B. At equal concentrations, benzoic acid has the higher concentration of H_3O^+.
C. If equal volumes of 0.10 M solutions of both acids are neutralised with 0.10M NaOH(aq), less is needed for benzoic acid.
D. At equal concentrations, lactic acid has the higher pH.

Question 2
Which of the following techniques would be a key analytical tool used in an analysis to identify an unknown organic compound?

A. Atomic absorption spectroscopy.
B. Gas chromatography.
C. Mass spectroscopy.
D. Thin-layer chromatography.

The following information applies to Questions 3,4 and 5.

Oxygen, $O_2(g)$, and Ozone, $O_3(g)$ can coexist in the atmosphere as part of the equilibrium $2O_3(g) \rightleftharpoons 3O_2(g)$, $\Delta H = -285.4$ kJ mol^{-1}.

At 298 K, $K_c = 1.62 \times 10^{57}$ M

Question 3

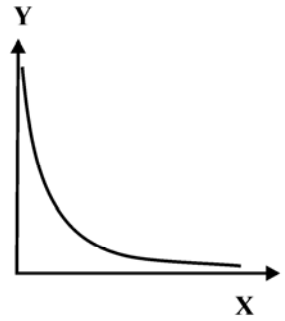
The ratio of O_3 to O_2 present in the atmosphere would be expected to increase as a result of

A. a decrease in atmospheric pressure.
B. lightning.
C. a sudden decrease in temperature.
D. extensive flooding.

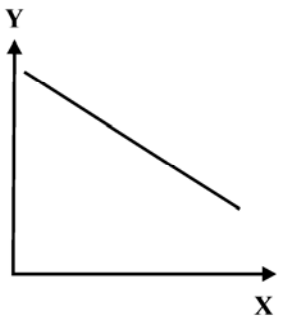
Question 4

Which of the graphs below best represents the change in value of the equilibrium constant with temperature for the reaction $2O_3(g) \rightleftharpoons 3O_2(g)$?

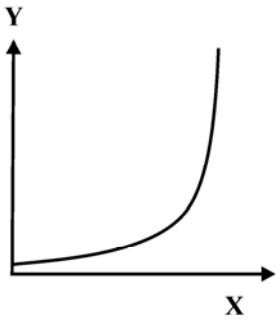
A.



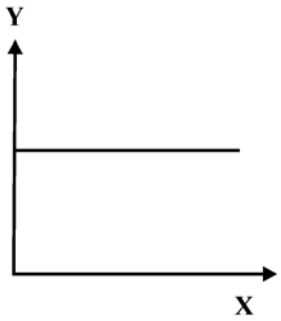
B.



C.



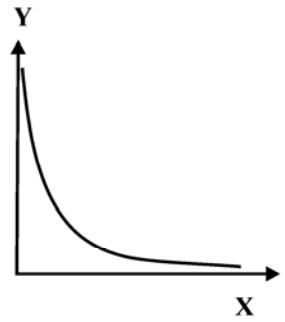
D.



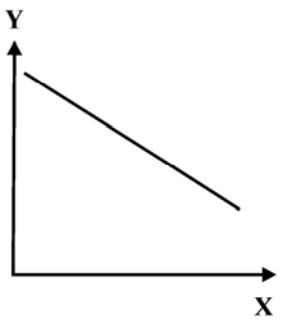
Question 5

Which of the graphs below best represents how the change in value of the equilibrium constant with pressure at constant temperature for the reaction $2O_3(g) \rightleftharpoons 3O_2(g)$?

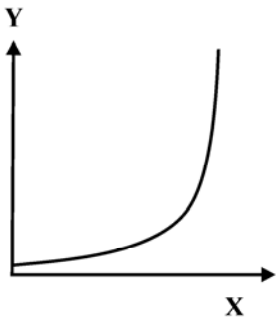
A.



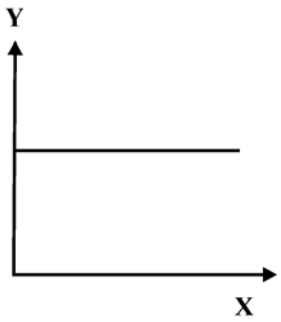
B.



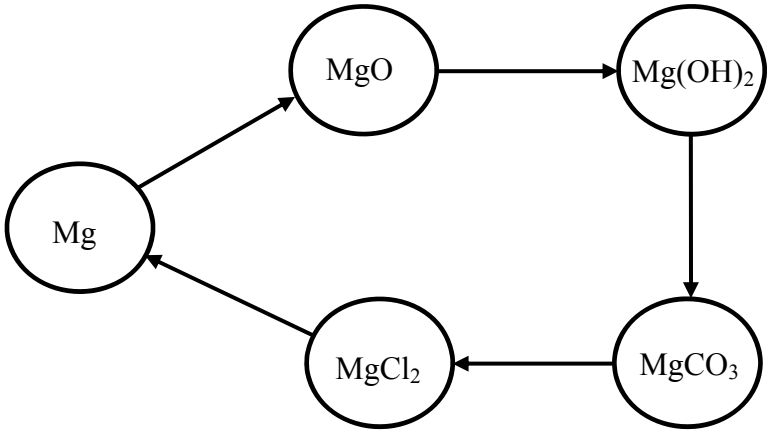
C.



D.



Question 6
The diagram below represents a sequence of reactions involving magnesium or its compounds.

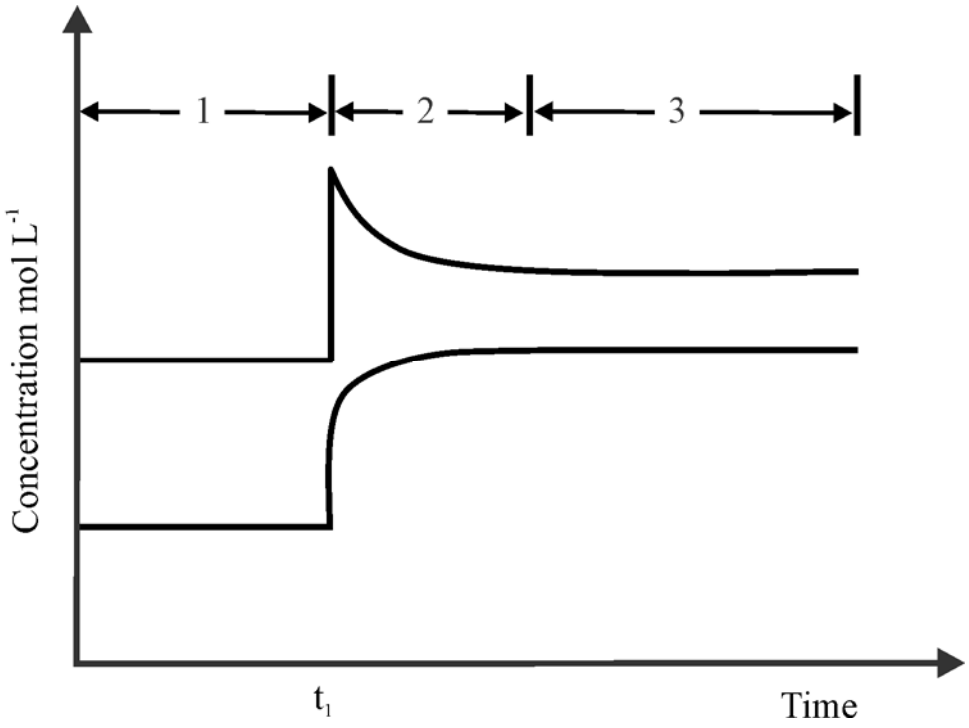


The smallest number of other elements or compounds required to complete the reaction sequence is
A. 3
B. 4
C. 5
D. 6

Question 7
A 100 g sample of a metal was heated to 100°C and then quickly immersed in 200 g of water in an insulated container. The water was initially at 22.6°C and when the water and the metal reached thermal equilibrium, the temperature had increased to 29.0°C.
What was the specific heat capacity, in J g^{-1} $°C^{-1}$, of the metal?
A. 0.376
B. 0.754
C. 3.26
D. 4.18

Question 8
Nitrogen molecules absorb ultraviolet light but not visible light, whereas iodine molecules absorb both visible and ultraviolet light. Which of the following alternatives best explains these observations?
A. Visible light does not contain the wavelengths necessary to make nitrogen molecules change their vibrational energy levels.
B. Nitrogen molecules are held together by triple covalent bonds and visible light is unable to change their nucleus spin energy levels.
C. Visible light does not produce transitions between electronic energy levels in nitrogen molecules.
D. More energy is required to break intramolecular bonds in nitrogen.

Question 9
The concentration-time graphs for a change imposed on an equilibrium system are shown below.



The change imposed at t_1 could have been

A. the addition of reactant to the equilibrium $3O_2(g) \rightleftharpoons 2O_3(g)$.
B. a decrease in the volume of the equilibrium $2O_3(g) \rightleftharpoons 3O_2(g)$.
C. a decrease in the temperature of the equilibrium $2NO_2(g) \rightleftharpoons N_2O_4(g)$.
D. an increase in the temperature of the equilibrium $N_2O_4(g) \rightleftharpoons 2NO_2(g)$.

Question 10
When a small piece of potassium metal was added to water in a beaker the following observations were recorded:

- the potassium spins vigorously and skims across the surface of the water.
- a lilac tinted flame is produced.

Which of the following statements best explains these observations?

A. The product of the reaction producing the flame was water.
B. The lilac flame was caused by electrons in potassium atoms moving to higher energy levels.
C. The pH of the solution formed during the reaction is less than 7.
D. Potassium is a stronger reductant than water.

Question 11
The relative peak areas for a mixture of four steroids separated by HPLC is given in the following table.

Compound	Relative peak area
Testosterone	32.4
Deoxycorticosterone	47.1
Norgestrel	40.6
Progesterone	27.3

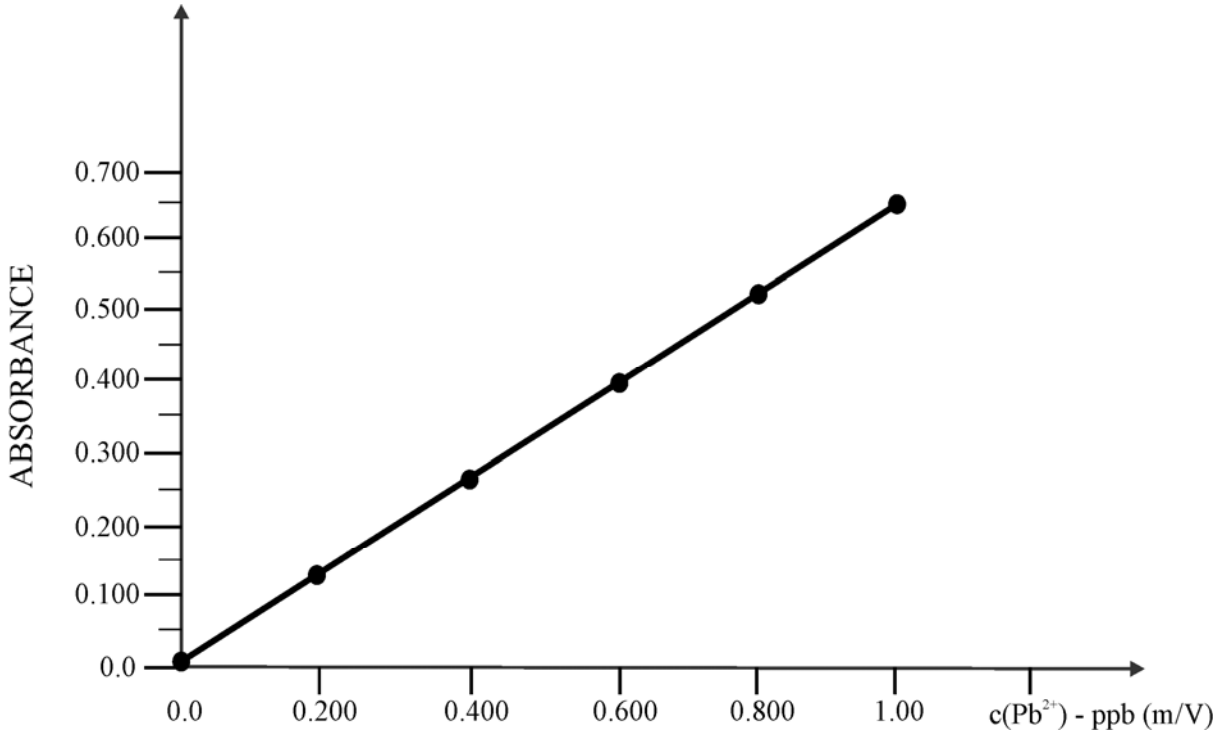
What percentage of the total steroid mixture was made up by Norgestrel?
A. 27.3
B. 27.5
C. 40.6
D. 47.4

Question 12
A mixture of the amino acids, arginine, lysine and phenylalanine are to be separated by reverse phase HPLC. In reverse phase chromatography, the stationary phase is hydrophobic and the mobile phase is hydrophilic. The expected order of elution from the column would be, in order of increasing retention time,
A. lysine, arginine, phenylalanine.
B. phenylalanine, arginine, lysine.
C. lysine, phenylalanine, arginine.
D. arginine, lysine, phenylalanine.

Question 13

Metals such as zinc and manganese are essential trace elements for animals and plants. However, heavy metals such as lead or cadmium are toxic, even at low concentrations. When cyanidin is added to an aqueous solution containing traces of heavy metals, it combines with them to produce species that absorb UV-Visible radiation. The species formed when cyanidin combines with lead absorbs at 390 nm.

A set of standards with known concentrations of $Pb^{2+}(aq)$ were made up and the absorbances measured at 390 nm. The calibration curve below was produced. (1 ppb (m/V) = 1 μg L^{-1}).



A 2.5 g sample of milk powder was added to water, along with cyanidin to make up 50.0 mL of solution. This solution was further diluted to 200 mL and the absorbance of the diluted solution at 390 nm, measured and recorded as 0.260.

The lead content of the milk in ng g^{-1} is closest to

A. 0.375
B. 7.5
C. 30
D. 150

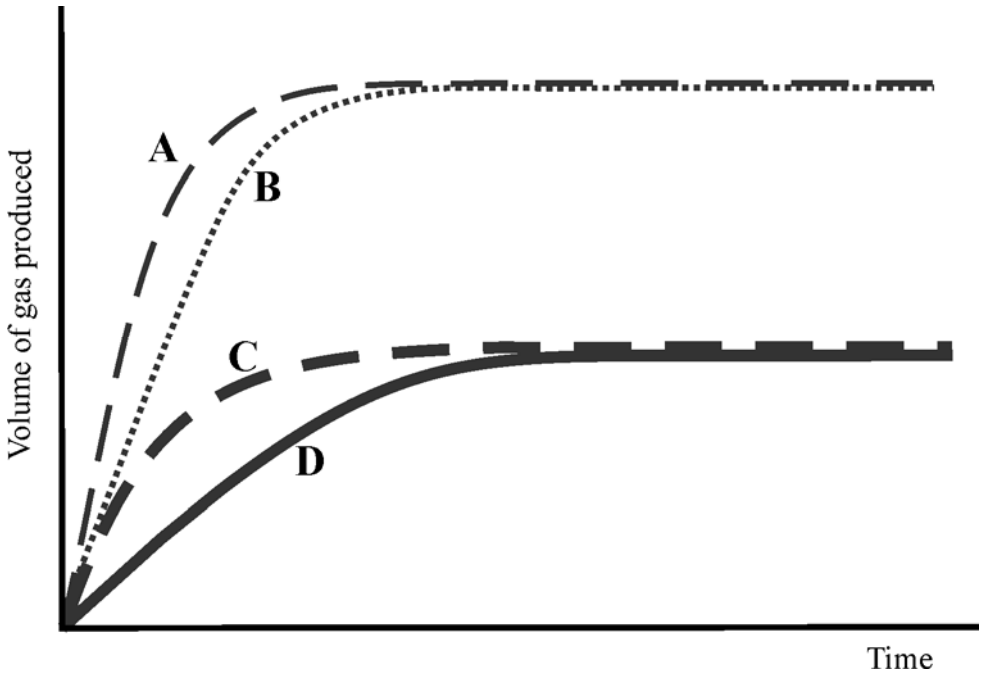
Question 14

Magnesium carbonate reacts with dilute nitric acid according to the equation

$$MgCO_3(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2\,(aq) + H_2O(l) + CO_2(g)$$

In an experiment to investigate the effect of different conditions on the rate of reaction between excess solid magnesium carbonate and 200 mL of nitric acid, the gas produced in the reaction is collected in a gas syringe and volume collected plotted against time for four different sets of reaction conditions.

The resulting graphs are shown below.



Which of the following statements is **not** consistent with the recorded data?

A. The size of $MgCO_3$ particles was not the same in all four investigations.

B. The concentration of HNO_3 was the same in all four investigations.

C. A catalyst may have been used in one or more of the investigations.

D. The initial temperature may not have been consistent across all four investigations.

Question 15

20 mL of 0.10 M propanoic acid is diluted to 100 mL with deionised water.

Which of the following is **not** an expected outcome of that change?

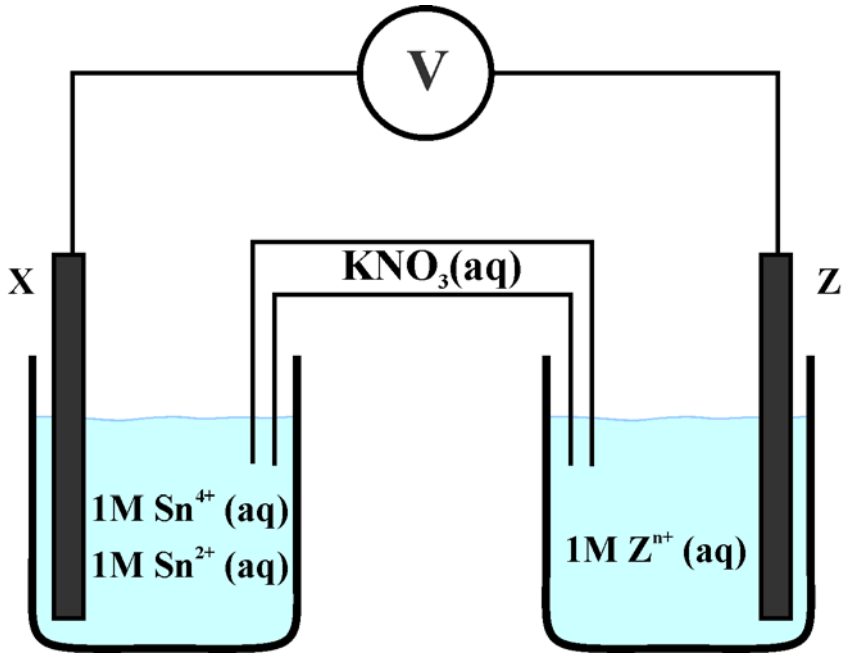
A. The $[H_3O^+]$ increases.

B. The number of $H_3O^+(aq)$ ions increases.

C. The pH increases.

D. The percentage ionisation increases.

The information below applies to Questions 16 and 17.
The diagram below represents a simple galvanic cell assembled in a laboratory.



Question 16
Which of the following elements would be **least** suitable for electrode X?
A. Carbon (graphite).
B. Silver.
C. Platinum.
D. Tin.

Question 17
If the galvanic cell has a potential difference of 1.53 V at 25°C,
A. the half-equation for the reaction at electrode Z is $Z(s) \rightarrow Z^{n+}_{(aq)} + ne^-$.
B. $K^+(aq)$ ions are moving towards electrode Z.
C. the cathode is electrode X.
D. the number of tin(IV) ions in the cell is decreasing.

Question 18
A food cannery is investigating using methane produced by bacterial decomposition of food waste to reduce the use of heating oil which has an average energy value of 38.5 MJ L^{-1}. What is the maximum volume of heating oil that would be saved if 2.45×10^5 L of methane, stored at SLC, is produced from food waste?
A. 43.3 L.
B. 231 L.
C. 636 L.
D. 2.56×10^3 L.

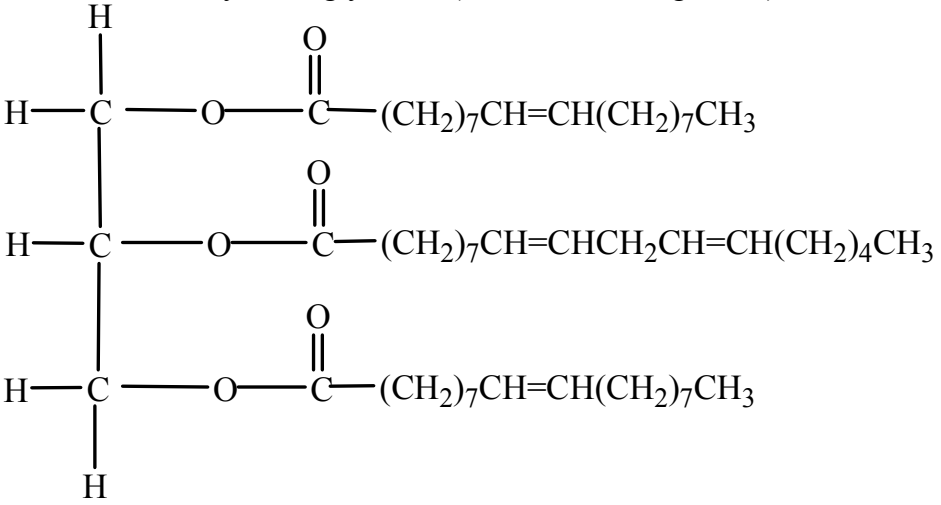
Question 19
A very well insulated bomb calorimeter contains 600 mL of water surrounding the reaction bomb. The calorimeter is calibrated electrically. The heat capacity of the calorimeter hardware, i.e. bomb and other solid components, is 785 J K^{-1}. The calorimeter constant would be closest to

A. 3.29 kJ $°C^{-1}$
B. 4.18 kJ $°C^{-1}$
C. 4.97 kJ $°C^{-1}$
D. 789 kJ $°C^{-1}$

Question 20
An unknown metal M forms a soluble compound, $M(NO_3)_2$.
When a constant current of 2.50 amperes is applied for 35.0 minutes to an aqueous solution of $M(NO_3)_2$, 3.06 grams of the metal M is deposited.
The metal M was

A. zinc.
B. strontium.
C. cadmium.
D. copper.

Question 21
A vegetable oil contains only the triglyceride (molar mass 882 g mol^{-1}) shown below



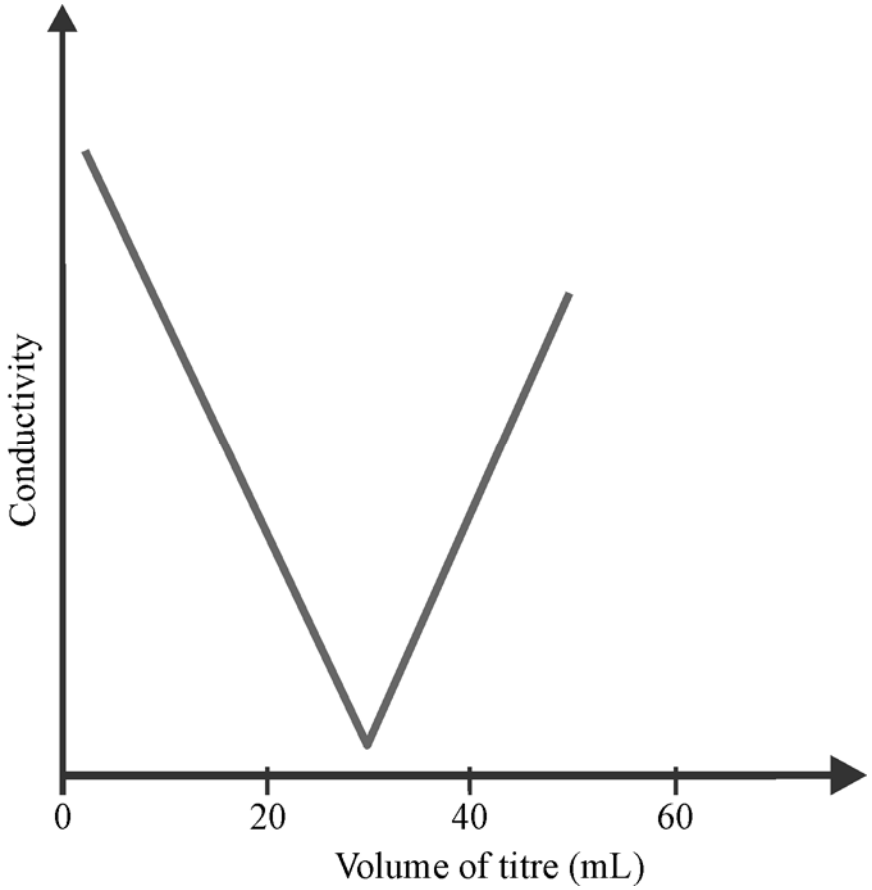
Which of the molecular compounds was **not** used in the production of the triglyceride?

A. Glycerol.
B. Stearic acid.
C. Oleic acid.
D. Linoleic acid.

Question 22
In aqueous solutions, amino acids often exist in the form of zwitterions. On **zwitterions**

A. the basic end is the $–NH_2$ and the acidic end is –COOH.
B. the basic end is $–NH_3^+$ and the acidic end is $–COO^-$.
C. the basic end is $–COO^-$ and the acidic end is $–NH_3^+$.
D. there is no basic or acid end since proton transfer occurs during the formation of a zwitterion.

Question 23
Shown below is a conductivity curve for the titration of 25.0 ml of $Ba(OH)_2(aq)$ with 0.10 M $H_2SO_4(aq)$.



The $Ba(OH)_2(aq)$

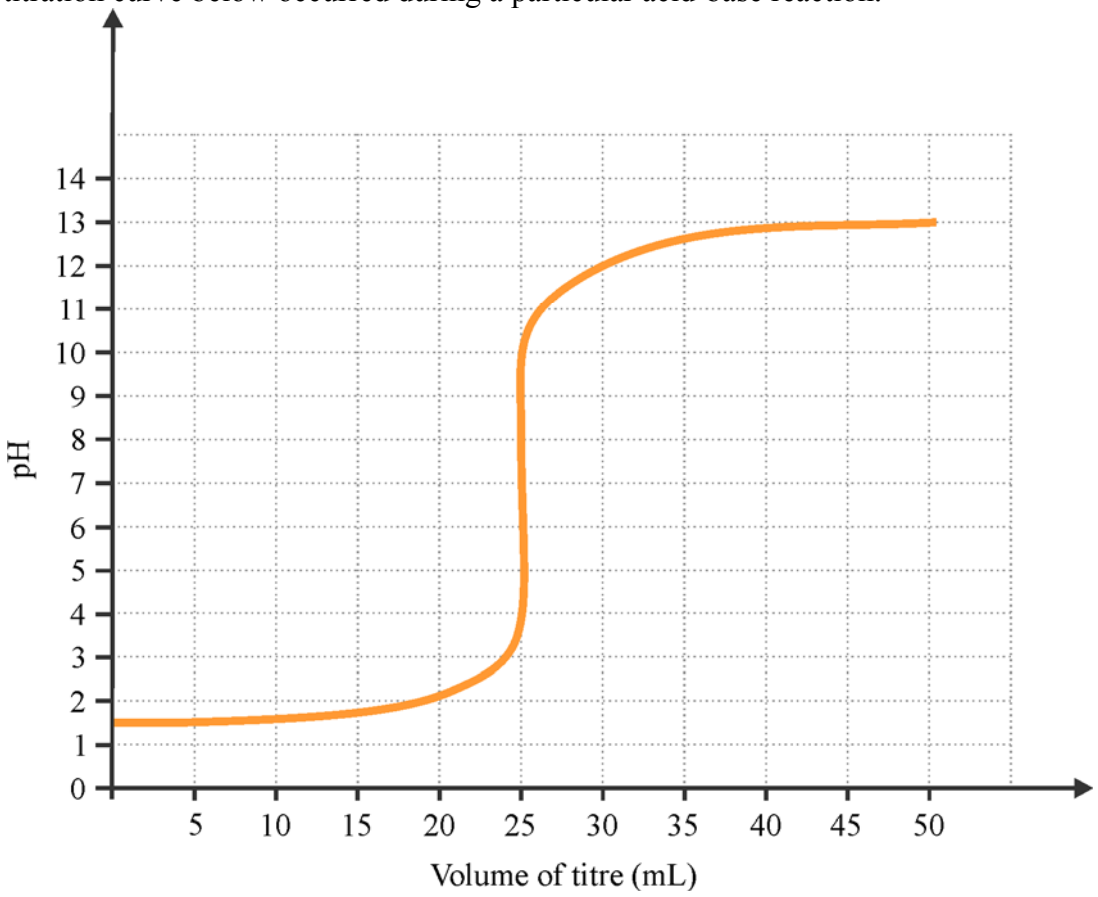
A. was in excess when 40 mL of titre had been added.
B. was originally 0.12 M.
C. was initially at pH 13.1.
D. released $Ba^{2+}(aq)$ ions which remained in solution throughout the titration.

Question 24
When an aqueous solution of ethanoic acid is titrated with an aqueous solution of sodium hydroxide, the pH at the equivalence point is 8.8.
The species that causes this pH value is

A. ethanoate ions.
B. hydroxide ions.
C. sodium ions.
D. ethanoic acid molecules.

Question 25
Some heart pacemakers are powered by lithium-iodide batteries. One of the electrodes is lithium metal and the other a solid complex of molecular iodine. The electrolyte is solid lithium iodide in a nickel mesh.
The overall equation for the energy releasing reaction is $2Li(s) + I_2(s) \rightarrow 2LiI(s)$.
What is the maximum amount of electrical energy that could be released by one of these batteries operating at 2.75 V and average current 85.6 μA over 10.0 years of operation?
A. 1.23 kJ
B. 856 J
C. 27.0 MJ
D. 74.2 kJ

Question 26
The titration curve below occurred during a particular acid-base reaction.



The solution in the titration flask prior to addition of any titre was most likely
A. 0.050 M sulfuric acid.
B. 0.010 M hydrochloric acid.
C. 0.030 M nitric acid.
D. 1.0 M ethanoic acid.

Question 27
A sample of anhydrous sodium carbonate, Na_2CO_3, is dissolved in enough water to make exactly three litres of solution. The concentration of this solution with respect to sodium ions, Na^+, was 0.0430 mol L^{-1}. The mass of Na_2CO_3 used to make this solution was

A. 3.42 g.
B. 5.35 g.
C. 6.84 g.
D. 13.7 g.

Question 28
At 200°C, nitrogen monoxide reacts with oxygen to form nitrogen dioxide as follows:

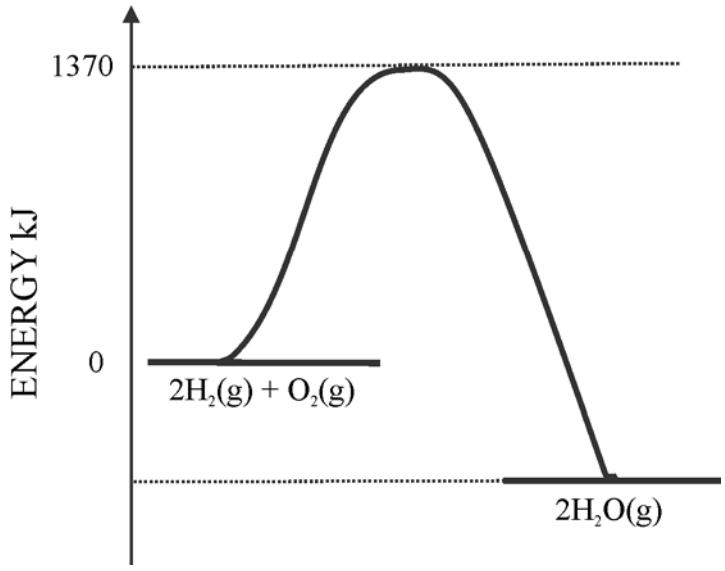
$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \quad K_c = 3\times10^6\ M^{-1}$$

If the concentrations in a particular mixture of these three gases, at 200°C, are 0.10 M NO, 0.10 M NO_2 and 0.010 M O_2,

A. the reaction is at equilibrium.
B. the reaction is not at equilibrium and must proceed from left to right to reach equilibrium.
C. the reaction is not at equilibrium and must proceed from right to left to reach equilibrium.
D. the reverse reaction is faster than the forward reaction.

Question 29
Shown below is some of the energy profile information for the reaction described by the equation:

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$



When the bonds between oxygen and hydrogen atoms form in 2 mol H_2O molecules,

A. 1370 kJ of energy is absorbed.
B. 286 kJ of energy is released.
C. 572 kJ of energy is absorbed.
D. 1942 kJ of energy is released.

Question 30

There are a number of landfill gas extraction facilities in Australia. Landfill gas contains approximately forty to sixty percent methane, with the remainder being mostly carbon dioxide.

Methane obtained from a landfill for use as a fuel is considered to be

A. a biofuel.
B. a non-renewable resource.
C. a fossil fuel.
D. a by-product of the chemical process occurring in the landfill.

End of Section A

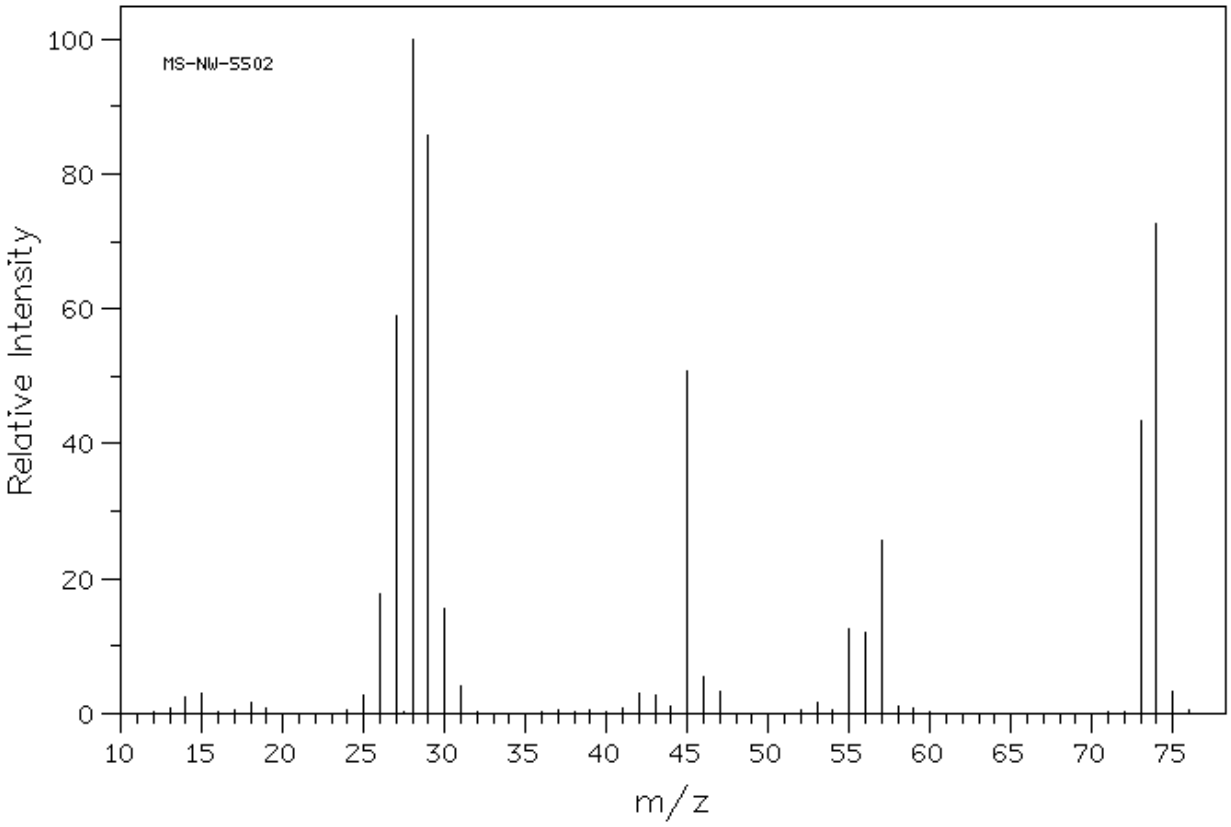
VCE Chemistry 2015 Year 12 Trial Exam Units 3/4

SECTION B – Short Answer Questions

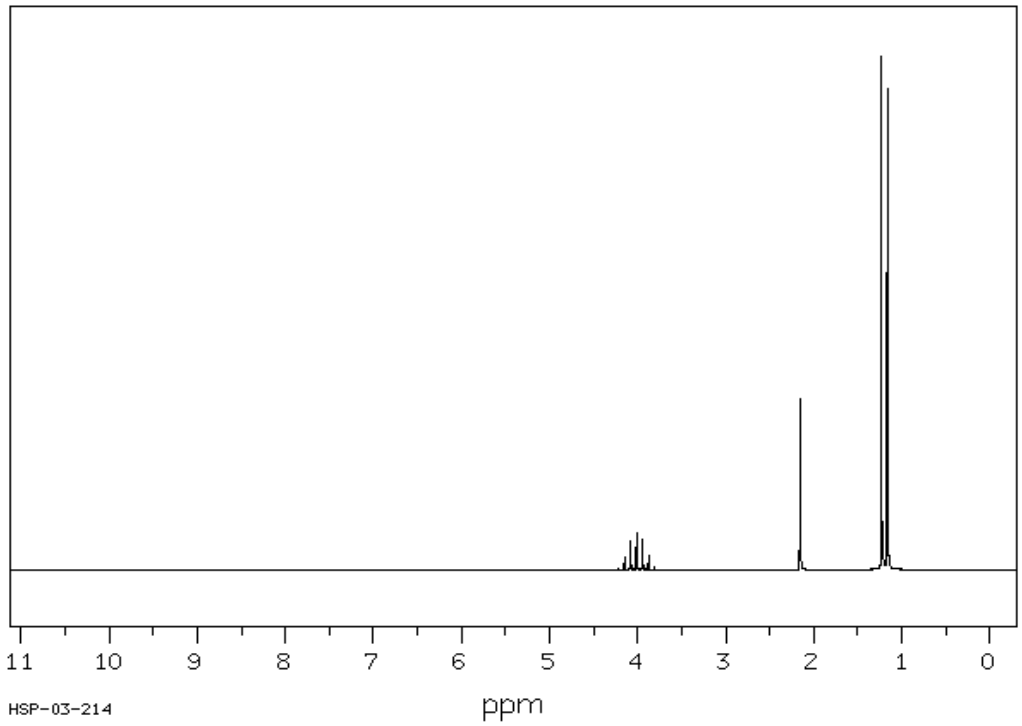
Section B consists of 7 short answer questions.
You should answer all of these questions in the spaces provided.
This section is worth approximately 78 per cent of the total marks available.
The marks allotted are shown at the end of each part of each question.

Question 1 (17 marks)
Consider the organic reaction pathways shown below.
A → B
C → D → E → F
Compounds A and C both contain the same number of carbon atoms but different numbers of hydrogen atoms. Compounds **B** and **E** are structural isomers with the same functional group.
Spectra for some of the compounds are provided below.

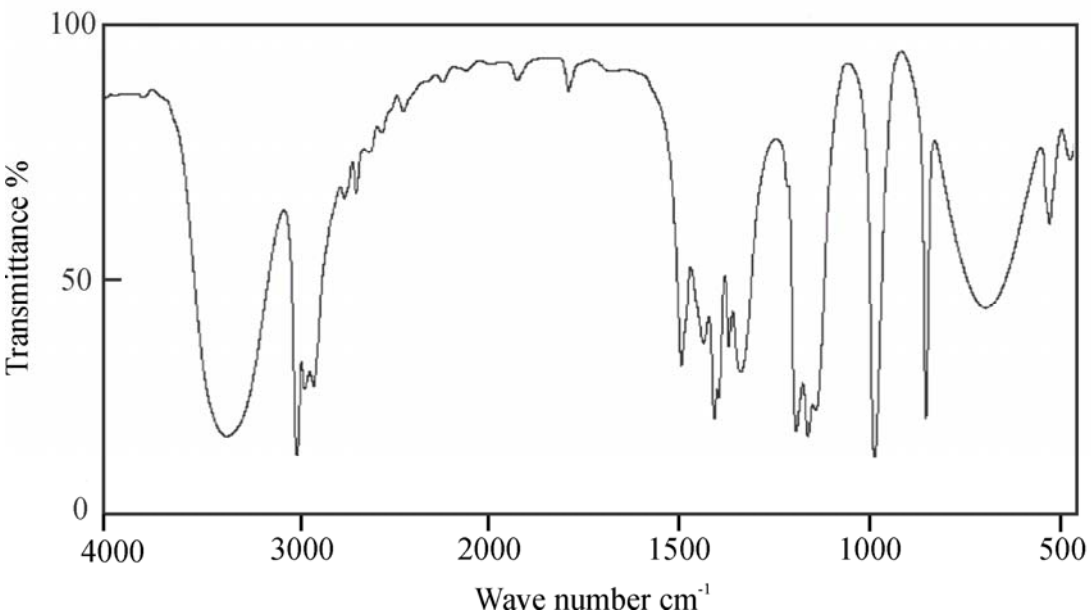
1. Compound F – mass spectrum



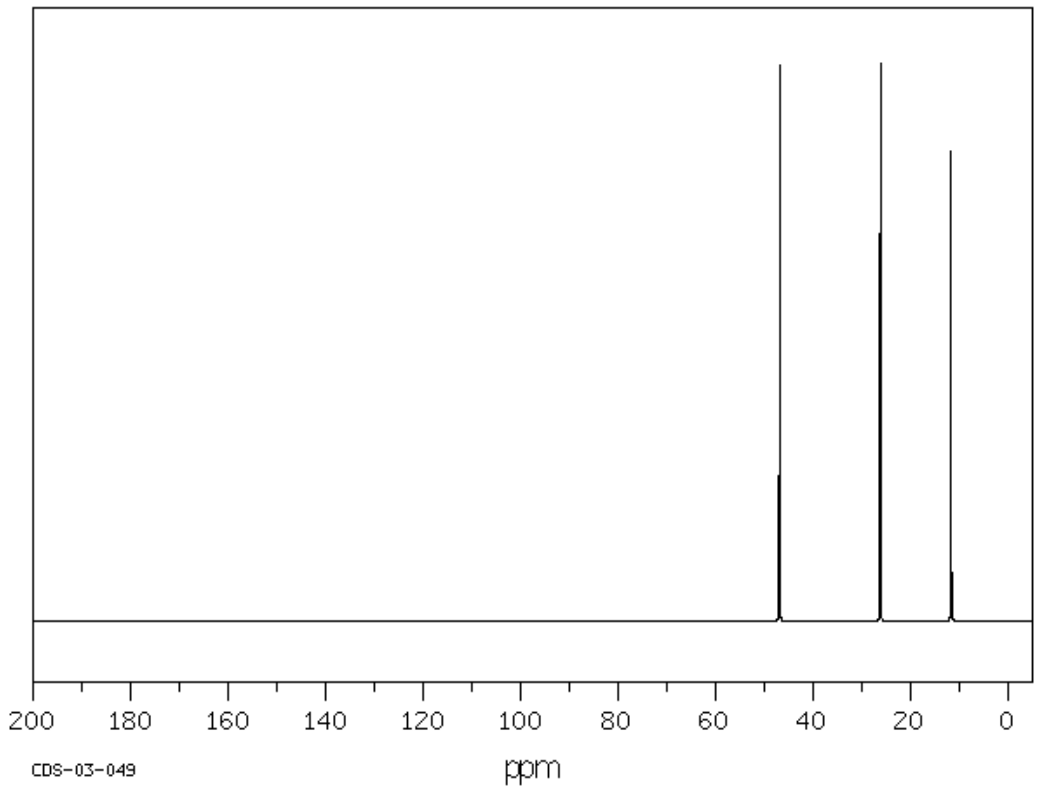
2. Compound <u>B</u> – ^{1}H NMR spectrum



3. Compound <u>E</u> – IR spectrum



4. Compound <u>D</u> – ^{13}C spectrum.



SDBSWeb: http://sdbs.db.aist.go.jp(National Institute of Advanced Industrial Science and Technology, 24/03/2015)

a. What is the most significant piece of information that can be deduced from the mass spectrum of compound F? **1 mark**

b. Explain how the ^{1}H NMR spectrum of compound B suggests that it contains three different hydrogen environments and that one of the carbon atoms in each molecule is bonded to a single hydrogen atom. **2 marks**

c. Explain how the IR spectrum of compound E enables the identification of the functional group present. **1 mark**

d. When solid sodium carbonate is added to compound F, gas bubbles are produced. Draw the full structural formula, showing all bonds of compound F. **1 mark**

e. **i.** Write the semi-structural formula of compound E. **1 mark**

ii. Give the full structural formula, showing all bonds, of compound B. **1 mark**

iii. Using half-equations justify the claim that the conversion of compound E to compound F is a redox reaction. **2 marks**

iv. Explain why compound B cannot be converted to compound F. **1 mark**

f. Compound C is converted to compound D by reaction with bromine.

i. Give the full structural formula, showing all bonds, for compound D and explain why this is consistent with its ^{13}C NMR spectrum. **2 marks**

ii. Write a balanced equation for the conversion of compound C to compound D. **1 mark**

g. Name compound A and write a balanced equation for its conversion to compound B. **2 marks**

h. When compound F is reacted with an alcohol in the presence of concentrated sulfuric acid, a compound, G, which has the same molar mass as pentanoic acid is produced.

i. Give the name of compound G. **1 mark**

ii. Write a balanced equation, using semi-structural formulae, for the production of compound G from compound F and the alcohol. **1 mark**

Question 2 (9 marks)

The thermochemical equation for the conversion of carbon to carbon monoxide is

$$2C(s) + O_2(g) \rightarrow 2CO(g) \qquad \Delta H = -221 \text{ kJ mol}^{-1}$$

a. Write a balanced thermochemical equation for the complete combustion of carbon to carbon dioxide. **1 mark**

b. Write a balanced thermochemical equation for the complete combustion of octane. **1 mark**

c. Use all three thermochemical equations to determine ΔH for the incomplete combustion of octane according to the equation

$2C_8H_{18}(l) + 17O_2(g) \rightarrow 16CO(g) + 18H_2O(l)$ **3 marks**

d. Part of a 200 mL sample of octane undergoes incomplete combustion and produces 100 L of CO, collected at 35°C and 102.3 kPa pressure. What percentage of the octane reacted? Density of octane is 0.703 g mL^{-1}. **4 marks**

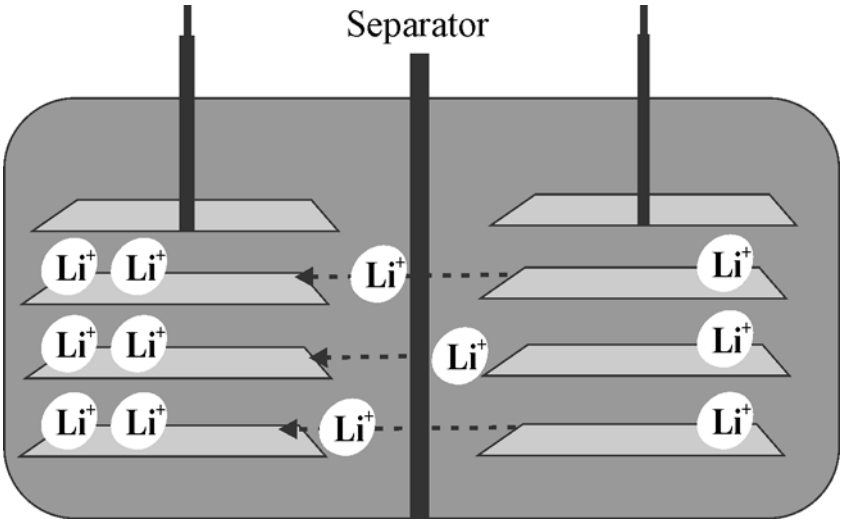
Question 3 (18 marks)

On April 30 2015, Elon Musk the CEO and product architect of Tesla Motors unveiled the Powerwall - a compact, wall mounted, rechargeable, lithium ion battery designed for homes and small businesses. The Powerwall will enable load-shifting where energy usage is spread for maximum benefit. The Powerwall can be charged using solar energy or less expensive off-peak electricity for maximum benefit.

Lithium-ion cells have solid electrodes which allow for the intercalation of lithium ions, i.e. lithium ions can become part of the electrodes without significantly affecting the structure. During operation, some lithium ion batteries have lithium intercalated graphite as one electrode material and a lithium intercalated transition metal oxide such as MnO_2 as the other. The overall discharge equation for these lithium-ion cells may be represented as $Li_xC_6(s) + Li_{1-x}MnO_2(s) \rightarrow C_6(s) + LiMnO_2(s)$.

'×' represents the amount of lithium ions transferred between the electrodes.

a. Part of one cell of the battery during discharging is represented in the diagram below.



i. Show, on the diagram, the signs of the two electrodes. **1 mark**

ii. Write balanced equations for the reactions occurring at the two electrodes. **2 marks**

ANODE:

CATHODE:

iii. Write a balanced half-equation for the reaction occurring at the cathode when the cell is recharged. **1 mark**

b. One of the Powerwall batteries that will be available is rated at 7.0 kWh (kilowatt hour). One kilowatt per hour is equivalent to 3.6 MJ of energy.

i. Assuming coal to be carbon, what mass of coal, in kg, must be used to produce 7.0 kWh of electricity in a coal-fired power station if the conversion from chemical to electrical energy is 35 per cent efficient? **4 marks**

ii. What would be two main advantages of improved efficiency in coal power stations? **2 marks**

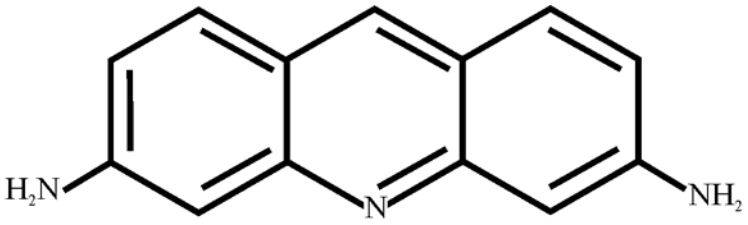
c. Identify a significant advantage that would be associated in integrating a Powerwall with a domestic solar energy system. **1 mark**

d. Energy from a Powerwall supply could be used to produce hydrogen by electrolytic decomposition of water. This hydrogen can then be used in hydrogen-oxygen fuel cells.

i. Write a balanced equation for the electrolytic decomposition of water. **1 mark**

ii. Write a balanced half-equation for the reaction occurring at the positive electrode in a hydrogen-oxygen fuel cell which has an alkaline electrolyte. **1 mark**

e. Intercalation is one of the methods by which DNA replication in cancerous cells can be inhibited. DNA intercalators fit in between nitrogen base pairs. Proflavine is an intercalator which may inhibit the replication of some bacterial DNA.
The structure of proflavine is shown below.



i. What is the molecular formula of proflavine? **1 mark**

ii. Discuss the links between nitrogen bases and the primary and secondary structures of DNA. **3 marks**

iii. Describe how proflavine might be expected to be attracted to nitrogen base pairs. **1 mark**

Question 4 (24 marks)

Iodine deficiency is the world's leading cause of preventable intellectual disability or mental retardation in children. If the diet is lacking in iodine, the thyroid, a gland that regulates many metabolic process such as growth and energy use, does not function efficiently.

In 2009 the mandatory fortification of baked bread with iodised salt was introduced in Australia in response to the re-emergence of mild levels of iodine deficiency in the population. The iodine in iodised salt may be present in the form of potassium iodide, KI, or potassium iodate, KIO_3

a. The recommended daily intake of iodine by an adult is 150 μg.
A particular brand of iodised salt contains 0.0055 per cent, by mass, of iodine in the form of potassium iodate.
What mass, in milligrams, of potassium iodate is present in a 500 g container of the iodised salt? **3 marks**

b. Potassium iodide tablets may be prescribed in cases of exposure to radiation that may damage the thyroid gland. Because potassium iodide is very bitter, such tablets also contain a soluble sugar as a filler. The iodide content of such tablets was determined by gravimetric analysis. One tablet was dissolved in 50.0 mL of distilled water and an excess of 0.20 M $Pb(NO_3)_2(aq)$ was added. A yellow precipitate formed and this was collected, washed and dried. The following data were recorded.

Mass of potassium iodide tablet	0.425 g
Mass of filter paper	1.462 g
Mass of filter paper and precipitate after first drying	1.775 g
Mass of filter paper and precipitate after second drying	1.699 g
Mass of filter paper and precipitate after third drying	1.698 g

i. Write a balanced ionic equation for the precipitation reaction. **1 mark**

ii. Explain why the precipitate was dried three times and how stopping at the first drying would affect the determination of the iodine content of the tablet. **1 mark**

iii. Determine the percentage, by mass, of iodine in the tablet. **3 marks**

c. Lugol's solution is a solution of iodine, I_2, and potassium iodide, in water and is used as an antiseptic and disinfectant. Iodine is normally sparingly soluble in water but in the presence of potassium iodide in Lugol's solution, its solubility is enhanced by the formation of the triiodide ion, I_3^- and the solution is in effect an equilibrium mixture described by the equation $I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$.
Lugol's solution can be used to distinguish between some carbohydrates.
In the presence of starch, Lugol's solution changes to a blue-black colour.
In the presence of glycogen, Lugol's solution changes to a brown-blue colour.
In the presence of simple carbohydrates, Lugol's solution retains its characteristic yellow-brown colour.

i. What do these observations suggest as a significant factor in the behaviour of Lugol's solution in the presence of carbohydrates? **1 mark**

ii. Referring to appropriate chemical reactions, describe the relationship between starch and glycogen in humans. **2 marks**

iii. Using chemical equations where appropriate, describe how glycogen is linked via one of the 'other carbohydrates' to respiration. **2 marks**

d. Triiodide ions are also produced by reaction between iodide ions and iodate ions in aqueous solution, according to the skeleton redox equation: $\_\_I^- + \_\_IO_3^- \rightarrow \_\_I_3^-(aq)$

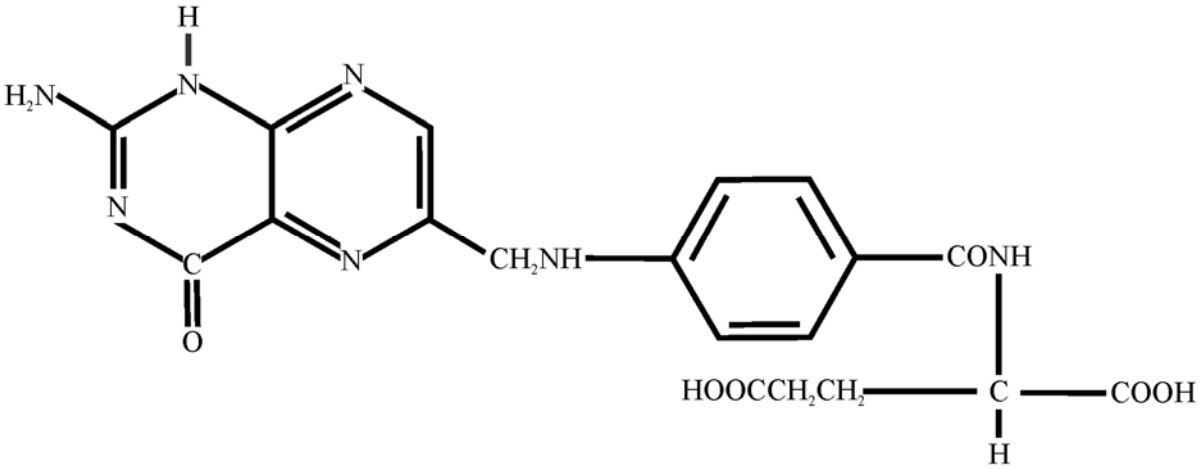
i. Use half-equations to establish a balanced overall equation for this production of triiodide ions. **3 marks**

ii. The concentration of $I_3^-(aq)$ in solution can be determined by titration with an aqueous solution of sodium thiosulfate, $Na_2S_2O_3(aq)$. In this reaction $S_2O_3^{2-}(aq)$ is converted to $S_4O_6^{2-}(aq)$ and triiodide ions to iodide ions. The equation for this reaction is

$$2S_2O_3^{2-}(aq) + I_3^-(aq) \rightarrow S_4O_6^{2-}(aq) + 3I^-(aq)$$

If a 25.00 mL sample of 0.0120 M KIO_3 was added to excess of KI and the product, triiodide, required 35.40 mL of $Na_2S_2O_3$ to reach the equivalence point, what is the molarity of the sodium thiosulfate solution? **3 marks**

e. Folic acid is also added to bread to reduce the likelihood of birth defects that may result from folate deficiency in pregnant women.
The structure of folic acid is represented below.



i. Circle and name three different functional groups on the molecule. **3 marks**

ii. Folic acid is much less soluble in water (1.6 mg mL^{-1}) at room temperature than it is in 1 M NaOH(aq) (50 mg mL^{-1}). Referring to the structure of folic acid molecules, discuss this difference in solubility. **2 marks**

Question 5 (18 marks)

Underground coal gasification (UCG) and gas to liquid conversion (GTL) are significant components of the industrial energy mix. One of the products of coal gasification is 'syngas', the major components of which are hydrogen and carbon monoxide which are major building blocks in the production of some liquid fuels.

Methods of syngas production include:

Steam methane reforming (SMR).

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g); \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$

Catalytic partial oxidation (CPOX) of methane

$$2CH_4(g) + O_2(g) \rightleftharpoons 2CO(g) + 4H_2(g); \qquad \Delta H = -76 \text{ kJ mol}^{-1}$$

a. For both processes, by referring to the effects of temperature and pressure, discuss the conditions that would provide optimum equilibrium yield of syngas. **3 marks**

b. Both processes benefit from the use of an appropriate catalyst. In which process would the use of a catalyst be of greatest benefit? Explain your answer. **2 marks**

c. One catalyst used in the CPOX production of syngas contains honeycombs of fused rhenium. Explain**,** in terms of collision theory, the benefits of such a catalyst. **2 marks**

d. A third method of syngas production is autothermal reforming represented by the equilibrium

$2CH_4(g) + O_2(g) + CO_2(g) \rightleftharpoons 3CO(g) + 3H_2(g) + H_2O(g) \qquad \Delta H = -31 \text{ kJ mol}^{-1}$

i. Write the equilibrium constant expression for autothermal reforming. **1 mark**

ii. What mass of syngas, in tonne, would be produced during the release of 310 MJ of energy in autothermal reforming? **3 marks**

e. Methanol, a liquid fuel, can be produced directly from syngas.

i. Write a balanced equation for the production of methanol from syngas. **1 mark**

ii. In which method of syngas production is the yield most suited to methanol production? Explain your answer. **1 mark**

iii. Based on your equation in **Question 5 e. i.** and the energy that would be released in combustion of the individual reactants and the product, determine whether the production of methanol from syngas is exothermic or endothermic and the ΔH value, in kJ mol^{-1} for the reaction. The molar enthalpy of combustion of CO is -293.5 kJ mol^{-1}. **3 marks**

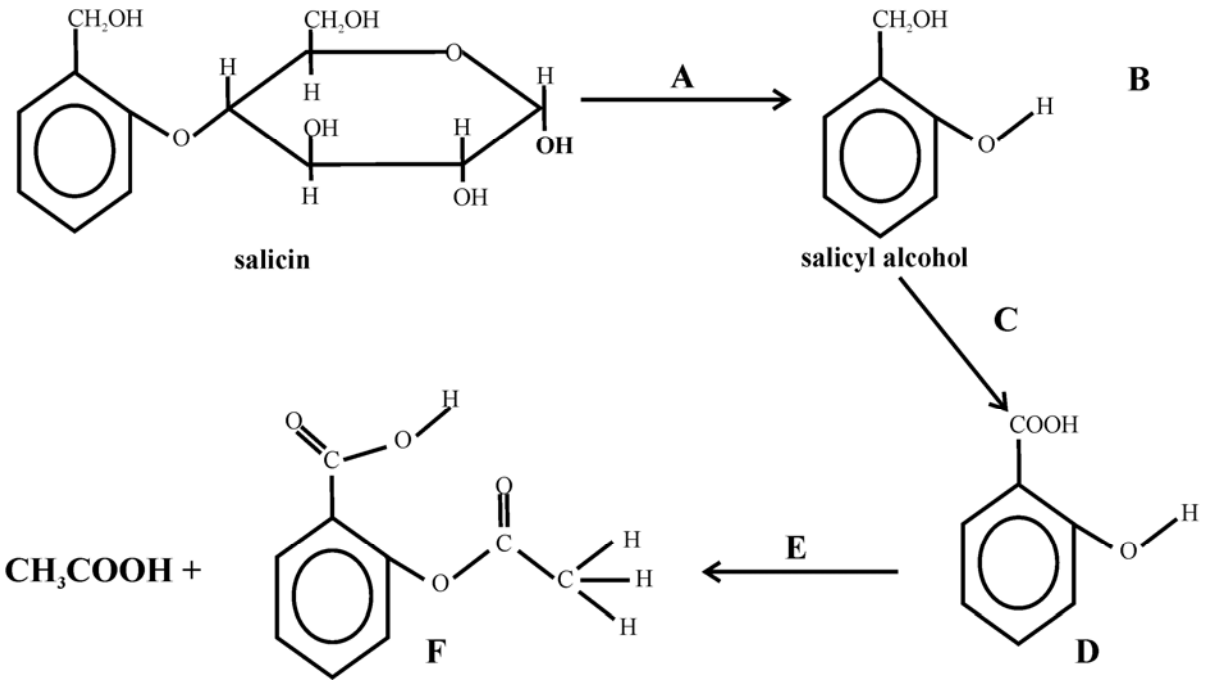
iv. Write a balanced thermochemical equation for the combustion of methanol. **1 mark**

v. Write a balanced equation for the reaction occurring at the (-) electrode in a methanol-O_2 fuel cell (acid electrolyte). **1 mark**

Question 6 (10 marks)

In 1829, Johan Büchner, isolated pure salicin from willow bark. Salicin was recognised as the 'active (pain relieving) ingredient' in willow bark. Subsequent derivatives of salicin proved to be more effective than salicin itself.

Shown below is a pathway for the production of a common pain reliever from salicin.



a. Write the common name of compound F **1 mark**

b. Write molecular formulae for compounds A and B. **2 marks**

A

B

c. Write the chemical formula(e) of the species represented by **C.** **1 mark**

d. Write the name of compound **E.** **1 mark**

e. Identify the types of reaction occurring in each of the three steps in the pathway. **1 mark**

f. 2.15 g of compound F was produced from salicin in this pathway where the process was 43 % efficient overall. What mass of salicin was used? **4 marks**

Question 7 (7 marks)
The electrolyses of water, 1 M LiCl(aq), and molten LiCl, i.e. LiCl(l) were investigated using carbon electrodes and a potential difference of 5 volts.

a. Write balanced half-equations for the reactions expected at

i. the (+) electrode in the electrolysis of water. **1 mark**

ii. the (-) electrode in the electrolysis of molten LiCl **1 mark**

iii. Explain why the pH increases at one of the electrodes during the electrolysis of water. **1 mark**

b. When 8 M LiCl(aq) was electrolysed instead of 1 M LiCl(aq), it was observed that the product at one of the electrodes was the same in the electrolysis of LiCl(l) but different to the product at the same electrode in the electrolysis of 1 M LiCl(aq). Using half equations, explain these observations. **4 marks**

End of Section B

End of Trial Exam