CHEMISTRY

UNIT 1 & 2

2017

MARKING GUIDE

Section One: Multiple-choice **25% (50 marks)**

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 ■

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 ☐

21	a ☐ b ☐ c ■ d ☐
22	a ☐ b ☐ c ■ d ☐
23	a ☐ b ☐ c ☐ d ■
24	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 ☐

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 ☐

(2 marks per question)

Section Two: Short answer **35% (70 marks)**

This section has **8** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

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: 60 minutes.

Section 2

Question 26. **(9 marks)**

A French brand of bottled vinegar called Vinaigre comprises a dilute solution of 7.50 g of acetic acid (CH_3COOH) in every 250 g of solution – call this solution X.

(a) Calculate the number of moles of acetic acid in the 250 g of solution X. (1 mark)

- **$n(C_2H_4O_2) = \frac{7.50}{60.052} = 0.1249$ mol**

b) Assuming that the volume of 250 g of Vinaigre solution X is 250 mL, what is the concentration of acetic acid in moles per litre? (2 marks)

- - **$c = \frac{n}{v} = \frac{0.1249}{0.25} = 0.500$ mol L^{-1}**

c) Write the equation for the ionisation of acetic acid. (2 marks)

- **CH_3COOH (l) $\leftrightarrow$ CH_3COO^- (aq) + H^+ (aq)** **- (1 mark for states)**

d) Acetic acid is classified as a **weak** acid. Explain what this means. (2 marks)

- **A weak acid is one that is not completely ionised in solution**
- **1 mole of acid would give less than 1 mole of hydrogen ions.**

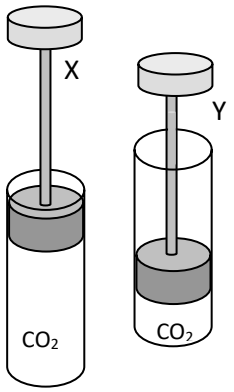
e) If the degree of ionisation of acetic acid is quoted as 1.3%, use your answer to part (b) to find the concentration of hydrogen ions in solution X. (2 marks)

- **1.3% 0f 0.500 mol** - **= 6.49 x 10^{-3} mol L^{-1} H^+ ions.**

Question 27 **(8 marks)**

Two positions of the same syringe are shown here.

A syringe shown in position X is filled with 540 mL of CO_2 at STP and then compressed to a smaller volume, as in position Y which is the same cylinder afterwards at the same temperature.



(a) Explain why the pressure in the cylinder has changed in going from position X to position Y in terms of the kinetic theory of gases (2 marks)

- **As the volume of the cylinder is reduced the spacing between the particles becomes less but the speed remains constant.**
- **The particles now have less distance to travel between collisions and so the collision rate with the walls increases, which increases the force on the wall and hence the pressure will be greater.**

(b) Calculate the mass of CO_2 in the cylinder s shown by diagram X. (3 marks)

Formula is $\mathbf{n = \frac{V}{22.71}}$

- $\mathbf{= \frac{0.540}{22.71} = 0.02378\ mol}$ **(2)**

- **Also m = nM = 0.02378 x 44.01 = 1.05 g. (1)**

(c) How does the mass of gas when in position X compare with the mass of gas when in position Y? (1 mark)

- **Matter is conserved, so the mass will be the same as before.**

(d) In going from position X to Y the gas volume was changed from 540 mL to 180 mL at the same temperature. Calculate the new pressure of the CO_2 inside the syringe at position Y. (2 marks)

- **$P_1V_1 = P_2V_2$ (Boyle's Law)**

  Standard pressure = 100 kPa

  100 x 0.540 = P_2 x 0.18 (1)

- **P_2 = 300 kPa (1)**

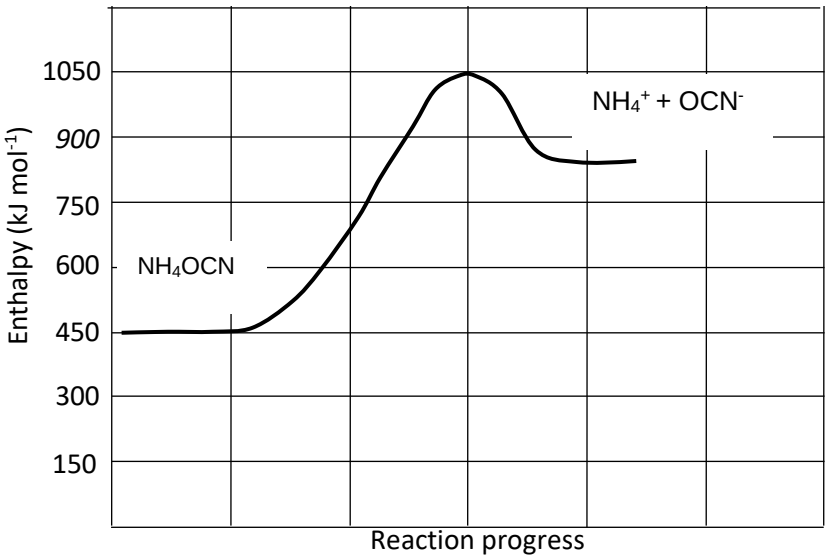
$PV = nRT$

$P \times 0.180 = 0.2378 \times 8.314 \times 273.15$ (1)

$P = \frac{0.2378 \times 8.314 \times 273.15}{0.180}$

$P = 300\ kPa$ (1)

Question 29 **(9 marks)**



The diagram above shows the enthalpy graph for a reaction where 0.50 mole of ammonium cyanate (NH_4OCN) crystals dissolves in water: $NH_4OCN\ (s) \rightarrow NH_4^+(aq) + OCN^-(aq)$

(a) Which are stronger, the NH_4^+ to OCN^- bonds in the NH_4OCN crystals or the ion-dipole bonds existing between H_2O and NH_4^+ ions and H_2O and OCN^- ions? Explain. (2 marks)

- **The ion-dipole bonds of H_2O-to-NH_4^+ and H_2O-to-OCN^- must be stronger than the ionic bonds in NH_4OCN crystals (NH_4^+ to OCN^-)**
- **Because the graphs shows the separated ions have a higher enthalpy (bond energy) value.**

(b) As the ammonium cyanate crystals dissolve how would this affect the surrounding solution? (1 mark)

- As the crystals dissolve they must absorb energy from the surroundings – hence the solution must get colder.

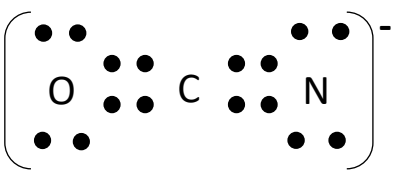
(c) What is the value for the Activation Energy for this reaction? (1 mark)

- **E_a = 1050 – 450 = 600 kJ mol^{-1}**

(d) What is the value for ∆H for this reaction? (Show the correct units) (2 marks)

- **∆H is about 380 kJ mol^{-1}** **- (830 – 450) accept (342 – 418 kJ mol^{-1})**

(e) Draw a Lewis (electron) Dot structure for the cyanate ion, OCN^-. (3 marks)



- **(correct electron numbers)**
- **(all atoms have 8 e's)**
- **(brackets shown with charge)**
- **also accept [O-C≡N]$^-$**

Question 30 **(8 marks)**

Consider the elements in Period 3 of the periodic table.

(a) Explain why chlorine has a higher 1st ionisation energy than magnesium. (3 marks)

- **Moving to the right of the Periodic table, the no. of protons in the nucleus is increasing.**

- Chlorine placed in the same energy level but has more protons attracting the valence electrons (3rd shell)
which produce a greater attraction for the outer electrons

- **If the force of attraction is greater for chlorine then more energy will be needed to pull the outer electron from the atom – Ionisation Energy.**

(b) Which has the higher ionisation energy, iodine or chlorine? (1 mark)

- Chlorine has the higher ionisation energy

(c) The S-Cl bond is a polar covalent bond. Explain what causes this polarity. (3 marks)

- The S and Cl atoms share the electron pair of the bond so they both have a stable 8 configuration.

- **However, the Cl atom has more protons and will attract the bonding pair to a greater extent (greater electronegativity)**
- **Thus the bond pair is pulled closer to the chlorine, making it slightly more negative and making the Cl – S bond polar (+ and – ends)**

(d) How does the polarity of molecules affect their physical properties? (1 mark)

- **Due to the molecules having + and – ends, adjacent molecules will be attracted to each other by electrostatic forces, raising the energy required to separate them and therefore raising the boiling point compared with non-polar molecules.**

Question 31 **(9 marks)**

Compound X is a strong electrolyte, compound Y is a weak electrolyte and compound Z is a non-electrolyte.

(a) Explain the differences between compounds X, Y and Z when dissolved in water in terms of their degree of ionisation and give an example of each type of substance. (6 marks)

- **Substance X will be an ionic salt, made from an acid and a base or a strong acid or strong base - they all fully dissociate in water.**
- **Substance Y is covalent but will partially dissociate in water**
- **Substance Z is covalent and produces no ions in solution**
- **Example of a compound like X: NaCl, etc, including partially soluble salts**
- **Example of a compound like Y: CH_3COOH, NH_3 or any weak acids and bases**
- **Example of a compound like Z: Sugar, kerosene or non-ionic organics.**

(b) Explain how you could tell the difference between water solutions containing 1 mole per litre solution of each of these substances. (2 marks)

- **To see which solution conducts best:**
- **Highest current recorded would be X, next highest would be Y and the non-conducting solution (zero current) would be Z.**

A farmer uses bore water pumped up from an aquifer which has been found to contain about 1% salt. Name a method by which the farmer could obtain pure drinking water from this salty bore water. (1 mark)

- **The farmer would have to use distillation apparatus (de-ionising column, etc)**

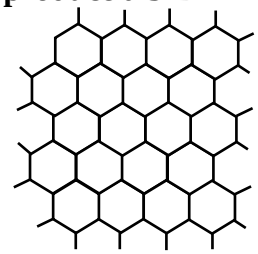
Question 32 **(9 marks)**

(a) Explain why carbon can form 3 dimensional structures, like diamond, but sulfur cannot. (3 marks)

- **Carbon has 4 valence electrons which means it has a bonding capacity of 4.**
- **4 bonds would repel each other according to the VSEPR theory to produce a 3-D tetrahedral structure.**

- Sulfur has only 2 bonding pairs which would repel into a 2-D planar structure.

(b) Explain why Graphene is a good conductor of electricity and yet diamond does not conduct at all. (2 marks)



Graphene

-In graphene carbon is only using 3 of its 4 valence electrons for bonding and hence each carbon atom has a spare electron available for conduction (delocalised).

- Diamond uses all 4 of its valence electrons for bonding and hence has none available to conduct charge.

Many women's make-up products contain nanoparticles of titanium dioxide which give the skin an attractive bright sheen. The size of the TiO_2 particles is around 100 nanometres.
Skin pores are small holes in the skin which allow entrance to the blood stream and are about 50 micrometres wide (50 x 10^{-6} m). (1 nanometre = 10^{-9} m)

(c) Explain why there might be concern over the use of nanoparticles in women's make-up.
(2 marks)

- **The pores (holes) in the skin are much larger than the nanoparticles used in make-up**
- **This means that nanoparticles can pass through the skin pores into the bloodstream and might cause medical problems.**

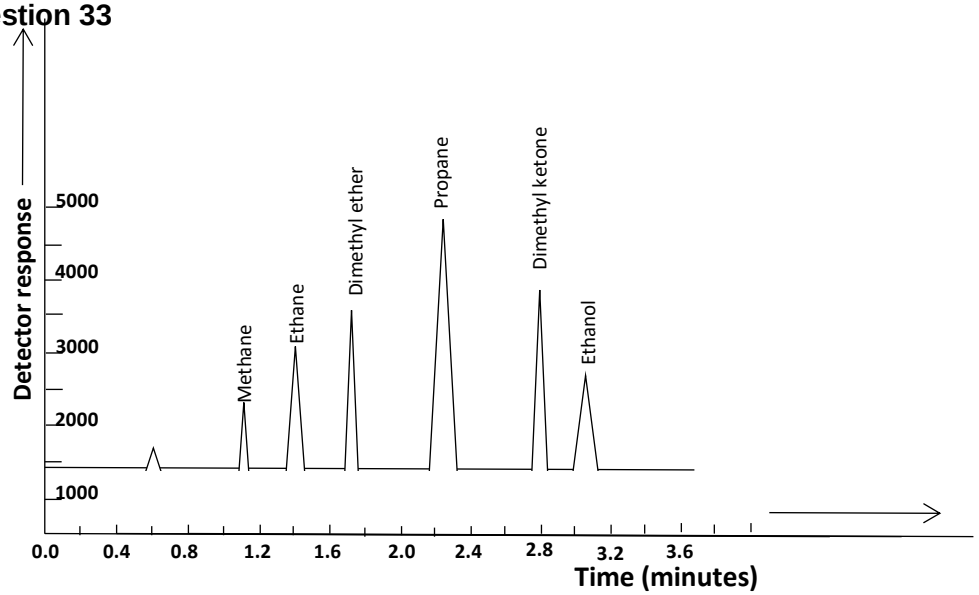
Graphene is over 300 times stronger than steel and can be used in bulletproof jackets. Diamond can be used to cut glass and gems but charcoal is an allotrope of carbon that is very soft.

(c) Explain why the charcoal allotrope is not as strong and hard as diamond and graphene
(2 marks)

- **Charcoal is an amorphous solid i.e. has no network structure linking atoms together which would give overall strength.**

- **Graphene and diamond have a giant network structure holding atoms in place with strong forces which makes for macroscopic properties of strength and hardness.**

Question 33 **(9 marks)**



Above is the detector read-out from a high performance gas chromatography apparatus analysing the organic residues inside a chemical reaction tank using a polar stationary phase in the column. The mobile phase used was helium which has a column retention time of 0.6 minutes, as seen from the graph.

(a) Which compound in the tank was present in the greatest concentration? (1 mark)

- Propane was present in the largest concentration as the peak is highest.

(b) Which compound had a Retention Factor of 0.34? Show calculations. (3 marks)

- $R_f = \frac{T_{He}}{T_s}$ so $\mathbf{0.34} = \frac{\mathbf{0.6}}{T_s}$
- $\mathbf{T_s} = \frac{\mathbf{0.6}}{\mathbf{0.34}}$ **= 1.76 minutes**

- This time corresponds to the substance <u>dimethyl ether</u>.

(c) Which compound being tested is the least attracted to the stationary phase? Explain. (3 marks)

- **Methane is non-polar**
- **It also has the least amount of dispersion forces and would not be attracted to the polar stationary phase and so would pass through the instrument more quickly**

- Methane takes the shortest time, apart from the mobile phase (1.15 minutes), hence is least attracted

(d) By considering the bonding types, explain why the Retention Time for ethanol would be the greatest. (2 marks)

- **Ethanol is highly polar as it can form hydrogen bonds**
- **This would make it highly attracted to the polar stationary phase and hence pass through the machine in the longest time.**

Section Three: Extended answer

Question 34 **(16 marks)**

A suggested method of removing CO_2 from the atmosphere is "Sequestration". Where the CO_2 is reacted chemically to produce a solid that can then be stored under the ground. One method of sequestration is to bubble CO_2 through a solution of calcium hydroxide, which produces calcium carbonate solid.

(a) Write a balanced equation for this reaction, including states. (2 marks)

- - $\mathbf{CO_2(g) + Ca(OH)_2(aq) \rightarrow CaCO_3(s) + H_2O(l)}$

(b) Calculate how many grams of calcium carbonate would be produced if 100 L of pure CO_2 at STP was dissolved in an excess of calcium hydroxide solution. (3 marks)

- $\mathbf{n(CO_2) = \frac{V}{22.71} = \frac{100}{22.71} = 4.403\ mol}$

  Ratio CO_2 : $CaCO_3$ is 1 : 1 so

- **$n(CaCO_3)$ = 4.403 mol**

  m = nM = 4.403 x (40.08 + 12.01 + 3 x 16)

- **m = 441 g.**

In one such sequestering experiment preformed in the laboratory, as above, 150 L of CO_2 collected at STP produced 6.00 x 10^2 g of calcium carbonate.

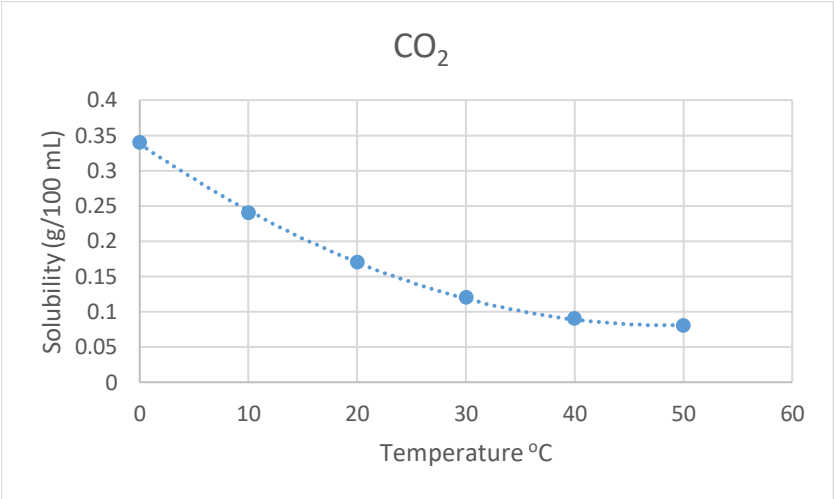
(c) From this figure, calculate the percentage efficiency of the experimental set-up.
($\%\ \text{Efficiency} = \frac{\text{Mass produced}}{\text{Calculated mass}}$ x 100) (3 marks)

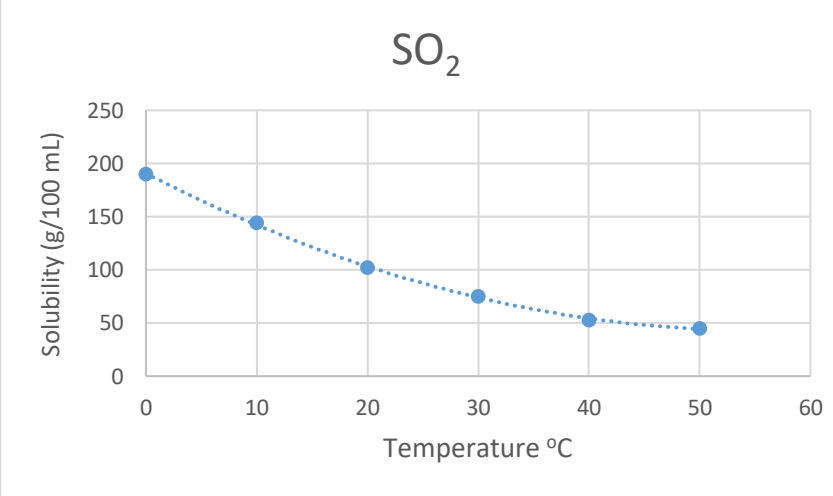
- $\mathbf{n(CO_2) = \frac{V}{22.71} = \frac{150}{22.71} = 6.605\ mol}$

  This should produce 6.605 mol of $CaCO_3$

- **Mass of $CaCO_3$ expected = 6.605 x 100.09 = 661.1 g**
- **% efficiency = $\frac{\text{Actual mass}}{\textit{Expected mass}} = \frac{600}{661}$ x 100 = 90.8%**

Graphs of the solubility values for CO_2 and SO_2 gases at different temperatures are shown below.





d) How many more times soluble is SO_2 compared with CO_2 at a temperature of 10°C? Show your working (2 marks)

- **Ratio of SO_2: CO_2 masses at 10°C is 148: 0.24**
- **Simple ratio is 617: 1 (accept from 583 – 620.83)**

SO_2, CO_2 and NO_X gases are emitted from coal-fired power stations and dissolve in rainwater to produce Acid Rain. This is a mixture of carbonic acid (H_2CO_3), sulfurous and sulfuric acids (H_2SO_3 and H_2SO_4 respectively), and nitric acid (HNO_3).

When acid rain falls on historic buildings made of marble, it causes them to dissolve.

e) Write a balanced equation, including states, for the reaction of nitric acid (HNO_3) reacting with marble ($CaCO_3$). (2 marks)

$$\mathbf{2HNO_3\,(aq) + CaCO_3\,(s) \rightarrow CO_2\,(g) + Ca(NO_3)_2\,(aq) + H_2O\,(l)}$$

A teacher keeps fish in a 50.0 litre tank outside the classroom which is at 10°C at night but rises to 20°C during the day.

f) Using the CO_2 graph, estimate the volume of CO_2 at STP that would have been absorbed into the fish tank at night time. (4 marks)

- **At 10° C 0.24 g of CO_2 in 0.1 L then mass in 50 L = 0.24 x (50/0.1) = 120 g**
- **At 20° C 0.17 g of CO_2 in 0.1 L then mass in 50 L = 0.24 x (50/0.1) = 85 g** (1)

Total difference in mass absorbed = 120 – 85 = 35 g (1)

- $n(CO_2) = m/M_r = 35/44.01 = 0.7953$ mol (1)

- $V(CO_2) = 22.71 \times 0.7953 = 18.1$ L (1)

Question 35 (16 marks)

Alkane	Boiling point (°C)
CH_4	-162
C_2H_6	-89
C_3H_8	-42
C_4H_{10}	-0.5
C_5H_{12}	36

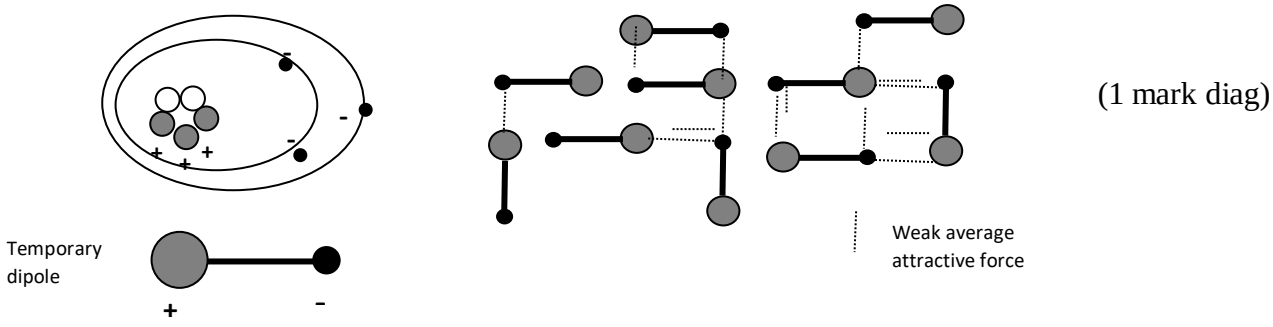
Above is a table of boiling points of some alkanes.

(a) Name the intermolecular force that is responsible for the rise in boiling points seen (1 mark)

- Dispersion forces.

(b) Explain, using diagrams, how this intermolecular force arises which allows one non-polar molecule to be attracted to another non-polar molecule. (3 marks)

- **Dispersion forces are caused by an attraction between temporary molecular dipoles**
- **These are formed because of the unequal distribution of electrons around atoms or molecules as there will be more electrons on one side of the species than the other for an instant.**



(1 mark diag)

(c) Refer to methane to explain what is meant by a **polar** bond and state whether the methane **molecule** is a polar. Explain your answer. (3 marks)

- A polar bond exists between the H and the C in a methane molecule because the C is more electronegative and attracts the pair of electrons in the C-H bond (1)
- Due to its opposing configuration the dipole vectors cancel out (total symmetry) in methane (1)

- and hence it is non- polar overall. (1)

(d) Explain why the arrangement of bonds in methane is said to be **tetrahedral**, rather than a flat cross planar configuration. (3 marks)

- **Each bond is an area of negative charge which will be repelled as far away as possible by the adjacent charge in another bond.**
- **There are 4 bonds between carbon and hydrogen**
- **VSEPR: In 3 dimensions, the furthest 4 bonds can separate is in a tetrahedral configuration, not as a planar cross.**

(e) Water has a molar mass similar to methane, and yet its boiling point is more than 200 degrees higher (100^{o}C). Explain why there is such a large difference in boiling points of these two substances. (3 marks)

- Water is a polar molecule and methane is non-polar

- This means that the intermolecular forces in water (H-bonds) are large and need more energy to separate i.e. higher temperature for boiling

- Methane molecules have only dispersion forces attracting them which are weak and hence need less heat (lower temperature) to separate them into the gaseous form

- Accept indication of the types of forces involved (2) and the relative strength of each type of force (1)

An unknown hydrocarbon X has a ratio of 2 hydrogen atoms for every carbon atom in its molecule. The molar mass of X was determined by mass spectrometer to be around 56 g mol^{-1}.

f) Use these data to determine the molecular formula of X. (3 marks)

- **If molecular formula were CH_2 then molar mass would be 12.01 + 2 x 1.008 = 14.026**
  If molecular formula were C_2H_4 then molar mass would be 2(12.01 + 2 x 1.008) = 28.052

  If molecular formula were C_3H_6 then molar mass would be 3(12.01 + 2 x 1.008) = 42.078
- **If molecular formula were C_4H_8 then molar mass would be 4(12.01 + 2 x 1.008) = 56.105 (several trials)**
- **This last formula would give a molar mass of close to 56.1 so the molecular formula must be C_4H_8.**

Question 36 **(16 marks)**

A farmer's property borders onto an old mine site and so some of his water supply is contaminated with dissolved silver salts.
He has one lake of clear water with a silver concentration of 3.75×10^{-4} mol L^{-1}.
The farmer decided to precipitate out the silver ions in a 5.00 L sample lake water by adding hydrochloric acid to produce insoluble silver chloride.

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

- - $\mathbf{Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)}$

(b) State a method he could use to separate this precipitate out from the water and explain the separation principle involved. (2 marks)

- **The process of <u>Filtration</u> would separate the precipitate and retain it in the paper.**

- **The filter paper has holes in which are smaller than the size of the particles of silver chloride and so they become trapped in the paper whilst the liquid passes through.**

Or any other reasonable separation technique and explanation

(c) Calculate the mass of silver chloride that would be expected from the 5.00 L of lake water. (3 marks)

- $\mathbf{n = cV = 3.75 \times 10^{-4} \times 5 = 1.875 \times 10^{-3}}$ **mol**
- $\mathbf{n(AgCl) = n(Ag) = 1.875 \times 10^{-3}}$ **mol** **(1)**
- $\mathbf{m(AgCl) = 1.875 \times 10^{-3} \times (107.9 + 35.45)}$ **(1)**
- **m = 0.269 g.** **(1)**

Having removed the silver from the lake water, the farmer attempted to produce pure water from the remaining 5.00 L of impure water.

(d) State the name of the process by which pure water could be obtained from impure water and list the apparatus that would be used. (3 marks)

Process name: - **Distillation**

Apparatus: **Includes** **- flask containing murky water being heated**

- Liebig condenser with cold water entering

Or reverse osmosis

After the water had been purified in this way, the remaining solid from the 5.00 L of lake water was found to be calcium nitrate leached from the soil around the lake, which had a mass of 3.76 g.

(e) Calculate the concentration of nitrate ions that would have been present in the lake water. (3 marks)

- $\mathbf{n(Ca(NO_3)_2) = \frac{3.76}{(40.08+14.01 \times 2+16 \times 6)} = 0.02291}$ **mol** **(1)**
- $\mathbf{n(NO_3^-) = 2 \times n(Ca(NO_3)_2) = 0.0458}$ **mol** **(1)**
- $\mathbf{c = \frac{n}{V} = \frac{0.0458}{5} = 9.17 \times 10^{-3}}$ **mol** $\mathbf{L^{-1}}$ **(1)**

f) Calculate the percentage of nitrogen in this fertilizer and the mass of nitrogen that would be added to the soil around the lake by the use of 150 kg of this fertilizer. (3 marks)

- - $\textbf{\% of nitrogen} = \frac{\textbf{2 x 14.01}}{\textbf{(2 x 14.01+4 x 1.008+3 x 16)}} \textbf{ x 100} = \textbf{35.0}\ \%$

- $\frac{\textbf{35}}{\textbf{100}} \textbf{ x 150} = \textbf{52.5 kg of nitrogen}.$

Question 37 **(16 marks)**

The ChemCom Company has been contacted to analyse a sample of soluble baby-milk powder by the government of a 3rd World country which suspects the powder contains unacceptably high concentrations of Pb^{2+} ions.

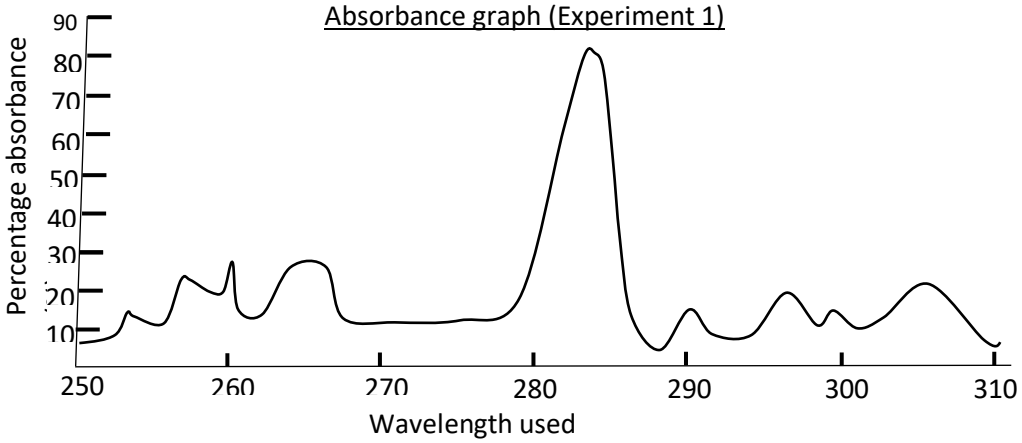
ChemCom uses an Atomic Absorption Spectrometer, where a selected wavelength of light λ_{Pb} would be absorbed by the Pb^{2+} ions present. λ_{Pb} is the wavelength having the greatest absorption by the lead ion.

a) Explain, in terms of atomic structure, why ions of lead (Pb^{2+}) would preferentially absorb this particular wavelength λ_{Pb}. (3 marks)

- **The particular wavelength λ_{Pb} represents a particular energy jump in the lead atom**

- **This energy is the amount absorbed when an electron is promoted from the a lower energy level (ground state) to a higher energy level within the lead atom.**

The graph below shows the results from Experiment 1, where the absorption of light at different frequencies by the lead ions in a solution of the milk powder is determined. (Note: 1 nanometre = 1 x 10^{-9} m)



(b) From the absorbance graph above estimate the wavelength that should be used in order to best detect the Pb^{2+} ions in the milk powder solution. (2 marks)

- **Answer a) is correct λ_{Pb} from the graph is 283 nm ± 2 nm**

(c) Explain why you chose your answer to part b)? (1 mark)

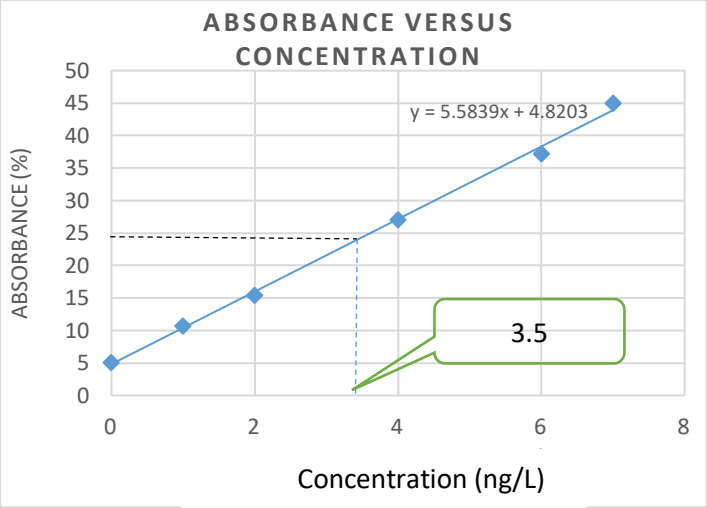
- **From the graph, at this wavelength the most energy is absorbed.**

For Experiment 2, solutions with known concentrations of lead were used to see how Absorption depends upon Concentration. The table below displays known concentration values and their corresponding Absorbance values. **Note:** Concentrations are measured in nanograms (ng) per litre (1 nanogram = 1 x 10^{-9} g)

Table

Concentration (ng per litre)	Pure water 0.00	1.00	2.00	4.00	6.00	7.00
Absorbance (%)	5.1	10.4	15.5	26.3	37.2	42.8

(d) Use the grid below to plot a labelled graph of absorbance on the vertical axis against concentration on the horizontal axis. (5 marks)



-Title (1 mark)

-Labelled x axes (1 mark), labelled y axes (1 mark)

-Points correct (1 mark)

-Line of best fit drawn (1 mark)

A sample of the milk powder to be tested was then added to water to make up a 100 mL solution and analysed in the Absorption Spectrometer for 3 trials.

The following results were obtained:

Trial	Trial 1	Trial 3	Trial 3	Average value
Absorbance (%)	24.3	24.7	24.0	

(e) (i) Calculate the average value of absorbance and insert this in the end column above. (1 mark)

-

Trial	Trial 1	Trial 3	Trial 3	Average value
Absorbance (%)	24.3	24.7	24.0	**24.3**

(ii) From the value you obtained for average absorption in part (i), calculate the concentration of lead in the foreign milk powder – expressed in ng L^{-1}. Show all construction lines on the graph and working below.

(2 marks)

- **Construction lines shown**
- **A figure of 24.3 absorbance gives a concentration value of 3.5 ng L^{-1} from the graph (allow ± 0.2)**

(iii) Express that answer to part (ii) in parts per million of lead in the solution i.e. the number of grams of lead in 1 million grams of solution (assume the solution has a mass of 1000 g per litre.) (2 marks)

- **3.5 ng in 1 litre = 3.5 x 10^{-9} g in 1000 g of solution**

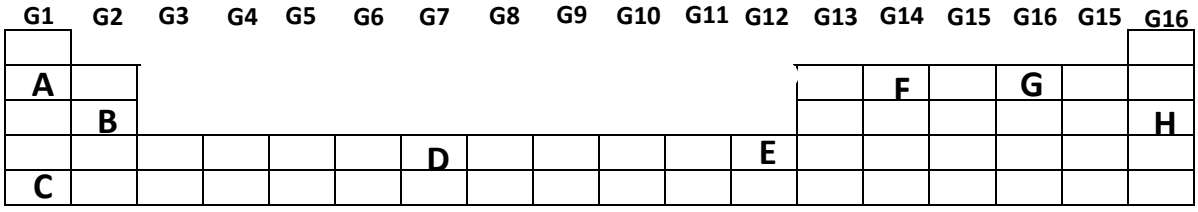
  In 1000,000 g of solution there would be 3.5 x 10^{-9} x 1000 g = 3.5 x 10^{-6} g per million grams

- **= 3.5 x 10^{-6} parts per million.**

(f) An alternative way of determine the amount of lead in the milk would be to precipitate the lead ions out by adding sodium sulfate and weighing the precipitate.
Name alternative solution of a compound that could be used to form a precipitate with lead ions, apart from sodium sulfate. (1 mark)

- **Any soluble salt with the following anions: CO_3^{2-}, PO_4^{3-}, Cl^-, I^-, Br^-, SO_4^{2-}, OH^-, CO_3^{2-}, S^{2-} would also form a precipitate**.

Question 38 **(16 marks)**



The diagram above illustrates part of the Periodic Table, as first arranged by Mendeleev. Some of the elements contained are shown as the letters A - H.

a) Which element would have an ion with a charge of 2 $^-$ and explain why it becomes charged in this way. (3 marks)

- **Element g (oxygen) would have a 2- ion as it has 6 valence electrons (1)**
- **Because, by gaining 2 electrons (1)**
- **it would achieve a noble gas structure which is particularly stable (1)**

(b) (i) Which of the elements shown would form a covalent compound? _____

(1 mark)

- **Elements F and G would form a covalent compound (CO)**

(ii) Give two possible formulas for this compound (use the proper elemental symbols from the Periodic Table for this) (2 marks)

- - **CO and CO_2**

(iii) Explain why these compounds would be covalent, rather than ionic. (3 marks)

- **No metal ion is involved**
- **The two elements would have to share electrons as they both have a high electronegativity**
- **By sharing one or more pairs of electrons, both elements can achieve a stable octet of valence electrons.**

(c) (i) Write the letters for elements that are Transition Metals in this table _____

(2 marks)

- - **Elements D and E are transition metals**

(ii) One of these transition metals was found to have 3 main isotopes. Name the instrument That is used to determine the atomic masses of these isotopes. (1 mark)

The mass spectrometer is used to determine the atomic mass of an isotope.

(d) The first four ionisation energies of element b are 736 kJ mol^{-1}, 1450 kJ mol^{-1}, 7740 kJ mol^{-1} and 10500 kJ mol^{-1} respectively.
Explain why the ionisation energies for successive electrons being removed from the atom have this pattern. (3 marks)

- **This element has 2 electrons in its valence shell (e.g. Magnesium)**
- **Ionisation energies from the 1st to the 2nd show a rising trend as the electron has to be removed from an increasing core charge core charge attracting the electron (736, 1450)**

- **The 3rd ionisation energy is so high because both valence electrons would have been removed from a shell much closer to the nucleus and the 7740 kJ value represents the energy needed to pull an electron from a full shell below, which is extremely stable** (noble gas structure) / greater attraction between the nucleus and remaining electrons.

(e) Which of the elements A – H, when bonded with hydrogen would produce a bond with the highest polarity?

(1 mark)

- **Element G would give the most polar bond with hydrogen (as it has the highest electronegativity in the list.)**