Chemistry for life 4 June 2001 2850 Length 1hr 30mins total mark 90
1)

Americium atomic number 95 is a radioactive metal. Household smoke detectors contain 150 micrograms of americium oxide (AmO_2) which emits alpha particles these are easily contained within the smoke detector but as they pass through the air they ionize it. This generates a tiny current across an air gap in the detector. When particles of smoke get into the gap they absorb the ions and the current drops causing the alarm to sound.

(a) The isotope of americium which is used is Am-241

(i) Give the numbers of protons neutrons and electrons in an atom of Am-241. (3marks)

(ii) What name is given to the number 241 in Am-241? (1mark)

(iii) This number can be found by using a mass spectrometer. A diagram of a mass spectrometer is given below. Describe how this instrument can be used to separate and detect isotopes of an element in the order to produce a mass spectrum in your description explain what is represented by the dotted line and refer to the processes taking at A-D (4marks)

    A- ionization chamber
    B- Electrically charged plates
    C- Magnetic Field
    D- Detector

(iv) A mass spectrum for a sample of americium is shown below.
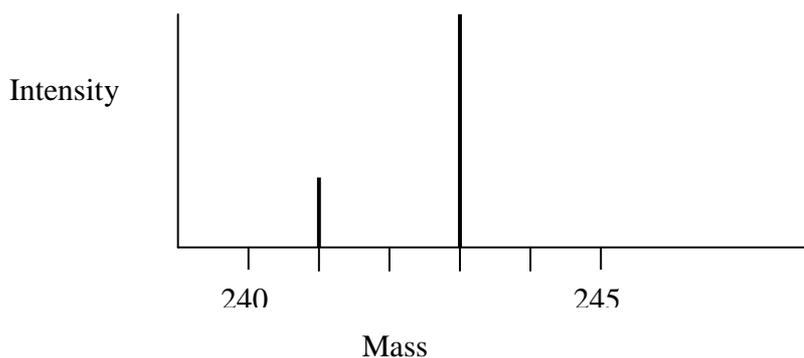
What can you deduce from this trace? (you are not expected to do any calculations all judgments should be made by eye) (3marks)

(b) Americium-241 emits alpha particles

(i) Complete the equation for this process

$^{241}_{95}Am \rightarrow$ (3marks)

(ii) Explain how alpha particles are easily contained with the plastic case of the smoke detector (2marks)

c) Americium metal forms a bright pink chloride. A sample is found to contain 70% by mass of americium and 30% by mass of chlorine calculate the empirical formula of the compound (A_r: Cl = 35.5; Am = 243) (2marks)

d) A sample of metallic americium can be made by reacting americium fluoride with barium metal at 1100 degrees Celsius.

(i)   Suggest formulae for the two different ions in americium fluoride (2marks)
(ii)   Construct a balanced chemical equation for the reaction of barium with americium fluoride. (3marks)
e) Americium has similar chemistry to magnesium

(i)   Describe the solubility in water of magnesium hydroxide (1mark)
(ii)   Complete the word equation for the action of heat on americium carbonate (2marks)

Americium carbonate $\rightarrow$

2) Mendeleeve first proposed his periodic table in 1869

a) i) which property of the elements did mendeleev use to arrange them in his table? (1mark)
    (i2)By which property are they arranged today (1mark)

Mendeleev left gaps for elements which he claimed would be discovered later. Two of these elements are shown as x and y in the simplified version of part of mendeleev's table below. The boiling points of the elements are given in Kelvin

| Mg 1363 | Al 2470 | Si 2638 | P 553 | S 718 | Cl 239 |
| Ca 1757 | X | Y | As 889 | Se 958 | Br 332 |

He predicted properties for elements X and Y. When these elements were later discovered their properties agreed with his predictions this made chemists take notice of mendeleev's table.
(b) Suggest a value for the boiling point of element Y giving reason (2 marks)
c) Predict the formula of the oxide of element Y giving a reason (2marks)

d)

i) State the number of electrons in the outer shell of element X (1mark)

(ii) Write the equation with state symbols for the first ionisation enthalpy of X (3marks)

    (iii)   The first ionisation enthalpy of X is smaller than the first ionisation enthalpy of aluminium give reasons for this. (2 marks)

3) What shall we do when crude oil runs out? One solution is to make hydrocarbons from coal using the fischer-tropsch process. The coal is first broke down into hydrogen and carbon monoxide. These gases are then reacted on the surface of a metal catalyst to produce long chain hydrocarbons. The mixture of hydrocarbons is separated and refined in the same way as crude oil.

A typical equation for the reaction on the metal surface is

$6CO + 13H_2 \rightarrow C_6H_{14} + 6H_2O$
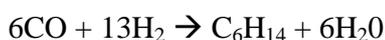
a) Compound P and compound Q are formed in this process. Both have the molecular formula C_6H_{14}

(i)   Name the homologous series to which both compounds belong (1 mark)

(ii)   Compound p has the formula $CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$ name this compound (1mark)

(iii)   Compound q is illustrated below (cant illustrated its 2-methylpentane) Give the full structural formula and the name of compound q (2mark)

    Name (1mark)

(iv)   What term is used to describe molecules which have the same molecular formula but different structures (1mark)

(v)   Which of P and Q would be better for use in petrol for a high compression engine? give full reasons for your choice in terms of octane ratings. (1mark is available for quality of written communication) (5 marks)

b) Compound p can be turned into a cycloalkane by the reaction shown
$C_6H_{14} \rightarrow C_6H_{12}$ + Substance R

    i)   What name is given in a refinery to this type of reaction (1mark)
    ii)   Identify substance R (1mark)
    iii)   Draw skeletal formula for the cycloalkane C_6H_{12} (1mark)
    iv)   Is the compound aliphatic or aromatic give a reason (1mark)

c) The catalyst for the reaction of carbon monoxide with hydrogen is thought to work like this:

Step 1 carbon monoxide decomposes on the catalyst surface and the separate atoms are adsorbed (bound to the surface) separately

Step 2 hydrogen molecules react with the bound atoms to form CH_2 (which remains adsorbed) and water (which is released)

Step 3 ch2 groups join up on the catalyst surface to produce chains which are then released

(i)   what type of catalyst is being described here (1mark)

(ii)   Complete the diagram below to show (for steps 2 and 3) the groups which are bound to the catalyst surface. (3marks)

CO

O   C

Catalyst Surface step 1

O   C

Catalyst surface step 2

H   H   H   H

C   C

Catalyst surface Step3
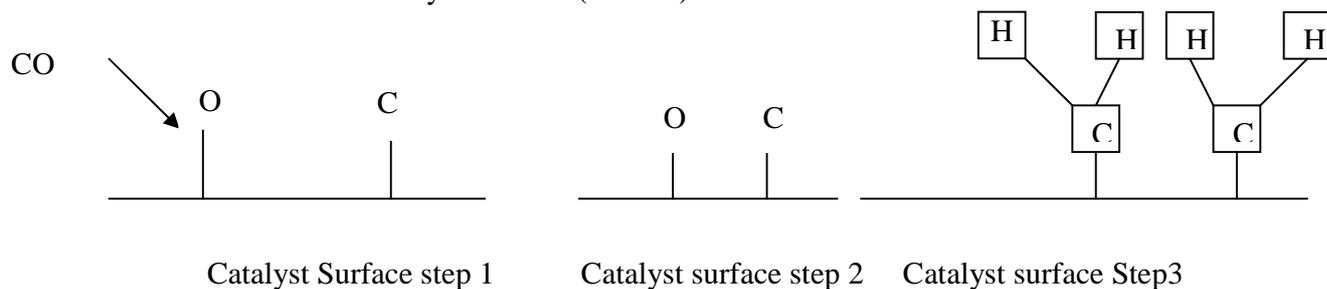
(iii)   Such catalysts are easily poisoned. What does the term catalyst poison mean ? (2marks)

d)   The overall equation for the reaction in c) is

$6CO(g) + 13H_2(g) \rightarrow C_6H_{12}(l) + 6H_2O(l)$ Equation 3.1
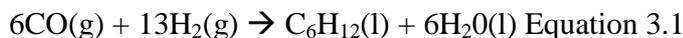
(I) Calculate the volume of hydrogen that would reaction exactly with 12 dm^3 of carbon monoxide the volumes being measured at room temperature and pressure. (2marks)

Ii) Calculate the mass of $C_6H_{14}(l)$ which would be formed from 12 dm^3 of carbon monoxide in (d) (i).
[Volume of 1.0 mole of molecules of gas at room temperature and pressure is 24dm^3 Ar C:12 H:1.0] (3 marks)

Iii In the reaction in Equation 3.1 would the entropy of the system increase d decrease or remain the same ? give reasons for your answer (2marks)

(e) Carbon monoxide can be burnt as a gaseous fuel. Write a balanced chemical equation for the combustion of carbon monoxide use the data below to calculate the standard enthalpy change for the process in kJ mol^{-1} (3marks)
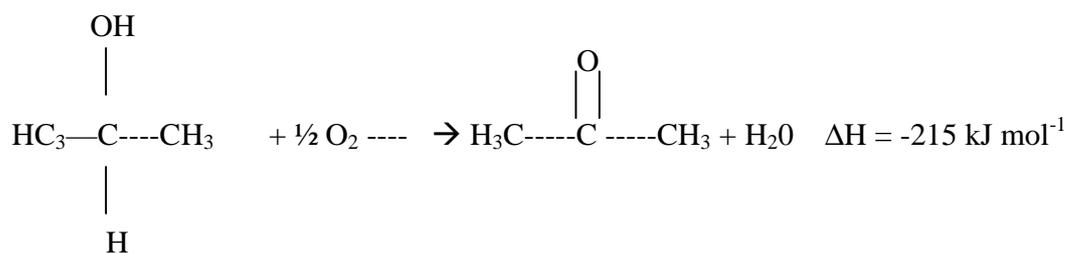
Standard enthalpy change of formation of CO_2 -393.5 kJ mol^{-1}
Standard enthalpy change of formation of CO   -110.5 kJ mol^{-1}

Equation:

Calculation:

(f) Draw a labeled diagram of a simple apparatus that you would use to measure the energy given out by a sample of liquid fuel when it burns (3marks)

4) Propanone (acetone) is widely used as a solvent and to make polymers such as Perspex. Propanone is made by the catalytic oxidation of compound J both propanone and compound J are liquids at room temperature.

$$OH$$
$$|$$
$$HC_3\text{---}C\text{----}CH_3 \quad + \tfrac{1}{2} O_2 \text{ ----} \rightarrow H_3C\text{-----}C\text{-----}CH_3 + H_2O \quad \Delta H = -215 \text{ kJ mol}^{-1}$$
$$|$$
$$H$$

Compound J   Propanone

a) i) What name is given to the OH functional group in compound J in Equation 4.1? (1mark)
   ii) Give the systematic name for compound J (2marks)

   (iv)   Draw a skeletal formula for compound J (2marks)

b) I) Complete the dot-cross diagram for propanone, Showing the outer electron shells only. (3marks)

O

H		C		H

| C | | C |

| H | | H | | H | | H |
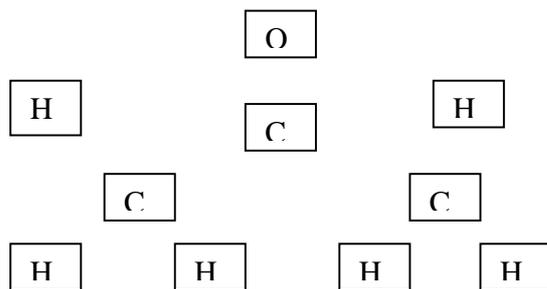
   (2i) Give the approximate values you would expect the angles a and b to have in the propanone molecule (2marks)
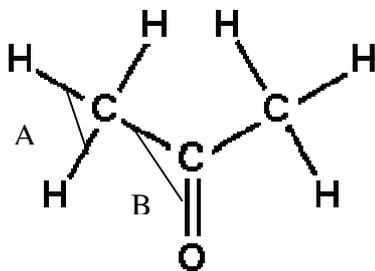
A =
B =

C) (I) Is energy released or absorbed when propanone is made from compound J?
Give a reason for your answer (1mark)

(iii)   Calculate the amount of energy released or absorbed when 3.0g of compound
          J are converted into propanone in equation 4.1 A^r C:12 H:1.0 O:16 (2marks)

D) Compound J would make a better fuel for cars than propane

i)   comment on this statement in terms of your answer in c)(i) (1mark)
ii)   Suggest four pieces of evidence you would need to evaluate this state more
          completely (4marks)