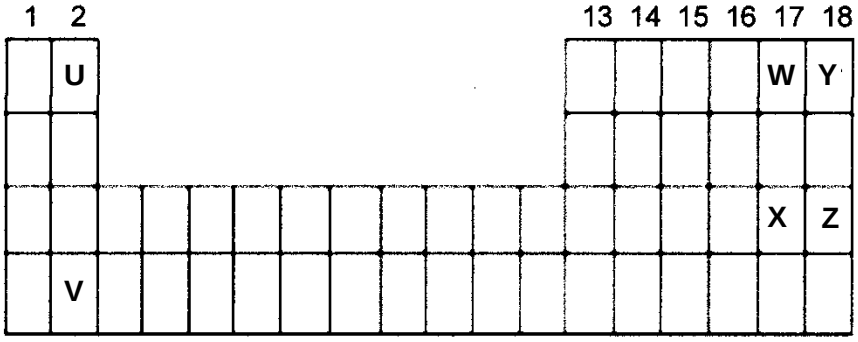
1ATAR Chemistry Intermolecular Forces and Gases Revision Test

Name: …….. Mark /135

Section 1: Multiple Choice (12 marks)

Answer all questions on the separate Multiple Choice Answer Sheet.

1. A section of the periodic table is shown below. The symbols for the elements are fictitious.



The element with the highest electronegativity is:

(a) U (b) V (c) W (d) X

2. In which of the following substances would hydrogen bonding occur?

I HF **II** NH_3 **III** H_2 **IV** HCℓ

(a) **I** and **III** only

(b) **II**, **III** and **IV** only

(c) **II** and **III** only

(d) **I** and **II** only

3. Which of the following best explains the difference in boiling points of HCℓ, HBr and HI, given their respective boiling points are -85, -67 and -35°C?

(a) The strength of dispersion forces increases as the number of electrons present in a molecule increases.

(b) The strength of hydrogen bonding increases as the number of electrons present in a molecule increases.

(c) The molecules become more polar as the number of electrons present increases.

(d) The strength of hydrogen bonds decreases as the number of electrons present in a molecule increases.

4. The correct order of increasing boiling points for the substances silica (SiO_2), propane ($CH_3CH_2CH_3$), ethanol (CH_3CH_2OH), and helium gas is:

(a) helium < propane < silica < ethanol

(b) helium < propane < ethanol < silica.

(c) helium < ethanol < propane < silica.

(d) propane < helium < ethanol < silica.

5. The shapes of many simple molecules can be predicted by the valence shell electron pair repulsion (VSEPR) theory. The VSEPR hypothesis states that:
   (a) orbitals in the outer shell of an atom stay as far away from each other as possible.
   (b) bonding pair electrons stay as far away from each other as possible.
   (c) non-bonding pair electrons stay as far away from each other as possible.
   (d) both bonding and non-bonding pair electrons stay as far away from each other as possible.

6. Consider the following substances in the molten (liquid) state:

   I $C_{10}H_{22}$ **II** NH_3 **III** $CH_3C\ell$ **IV** N_2

   Which of the above substances have only dispersion forces between their molecules?
   (a) None of the above
   (b) **II** and **IV** only
   (c) **II** and **III** only
   (d) **I** and **IV** only

7. Which of the following is the weakest type of molecular force or bond?
   (a) Hydrogen bond
   (b) Dipole-Dipole force
   (c) Dispersion force
   (d) Covalent bond

8. Which of the following is **not** a unit of gas pressure?
   (a) mmHg (b) N (c) atm (d) Pa

9. Which of the following is true?
   (a) The molar volume of a gas at STP is 24.5 L.
   (b) Gas volume is directly proportional to gas pressure.
   (c) Temperature and gas pressure are inversely proportional.
   (d) Gas pressure and temperature are directly proportional.

10. Kinetic energy of particles in a reaction is a measure of?
    (a) Temperature
    (b) Pressure
    (c) Volume
    (d) Heat

11. Which of the following solutions has the lowest freezing point and the highest boiling point?
    (i) 0.100 mol L^{-1} sucrose
    (ii) 0.050 mol L^{-1} $CaCl_2$
    (iii) 0.050 mol L^{-1} NaCl
    (iv) Distilled water

12. A test tube contains a clear, colourless salt solution. A few drops of lead nitrate solution are added to the solution and a yellow precipitate forms. Which one of the following salts was dissolved in the original solution?
    1. NaI (b) KCℓ (c) K_2CO_3 (d) K_2SO_4

Section 2: Short answer

Answer all questions in the spaces provided. (36 marks)

1. Complete the following table for the listed molecules. Include any lone pairs of electrons that influence the shape. (7 marks)

Molecule	Electron Dot Diagram	Shape	Dominant Intermolecular Force
$C\ell_2O$			
Hydrogen cyanide			
CF_4			
$AsBr_3$			
$C\ell_3^+$			NOT REQUIRED

2. Briefly explain the following, using diagrams where appropriate:

(a) Some covalent bonds are polar and some are non-polar. (3 marks)

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(b) The molecule boron trichloride is non-polar but nitrogen trichloride is polar. (6 marks)

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(c) Gases diffuse quickly. Refer to the Kinetic Theory of Gases in your answer. (3 marks)

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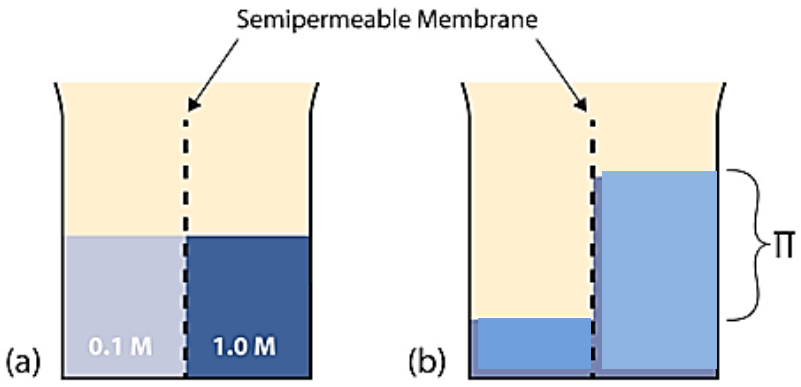
3. Consider the diagram shown. Two salt solutions of differing concentrations are placed on either side of a semipermeable membrane.

The pressure exerted by the different height of the solution on the right is called the osmotic pressure, π.



(a) What is the name of the process illustrated? (1 mark)

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(b) On the diagram (a) show the name and the direction of movement of the liquid molecules that selectively pass through the membrane. (2 marks)

(c) When the osmotic pressure exerted by the different height of the solution on the right is stable, state the concentration of the solutions. (1 mark)

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(d) Give an application of a form of the process illustrated. (1 mark)

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4. (a) Explain why water boils at only 71°C at the top of Mt Everest. (3 marks)

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(b) When pure water is heated, the temperature rises until it begins to boil and the temperature remains constant until all the water is evaporated. When a salt solution is heated, the temperature continues to rise even after it begins to boil. Why? (3 marks)

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5. (a) Explain how volume of a gas affects pressure at a set temperature. (2 marks)

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(b) Calculate the partial pressure of the oxygen when 1 mole of oxygen and 2 moles of nitrogen are the only two gases in a container where the total pressure is 450 kPa. (2 marks)

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6. The vapour pressure for water is 2.34 kPa at 20°C while the vapour pressure of acetone (CH_3COCH_3) is 24.6 kPa at 20°C. Explain what vapour pressure is and why water and acetone have such different values. (5 marks)

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Section 3: Calculations **(16 marks)**

Answer all the questions in the spaces provided. All numerical answers should be given to 3 significant figures.

7. What mass of solid NaOH would be required to prepare 100 mL of a 0.15 M NaOH solution? (2 marks)

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8. A beaker contains 345 mL of a 1.50 mol L^{-1} NaCℓ solution. If the salt solution is boiled until the volume of the solution is 250 mL, what will the molarity of the solution be? (2 marks)

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9. How much water would need to be added to 500 mL of a 2.40 mol L^{-1} KCI solution to make a 1.0 mol L^{-1} solution? (2 marks)

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10. What mass of carbon dioxide gas will be produced when 5.00 L of propane at STP combusts in plentiful air? (5 marks)

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11. What pressure will be exerted by 20.16 g of hydrogen gas in a 7.50 L cylinder at 20.0°C? (3 marks)

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Section 4: Extended Answer

Answer all questions in the spaces provided. (71 marks)

12. (a) Write a balanced ionic chemical equation for the reaction when 0.5 mol L^{-1} iron (III) sulfate solution and 0.5 mol L^{-1} sodium hydroxide solution are mixed. State the expected observations. (2 marks)

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(b) When an excess of silver nitrate solution was added to 10.0 mL of sodium chloride solution, 0.780 g of silver chloride was precipitated.

(i) Write a balanced ionic chemical equation for the reaction. State the expected observations. (2 marks)

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(ii) Find the concentration of the sodium chloride solution in mol L^{-1}. (3 marks)

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13. Fluorine forms compounds with many other elements.

(a) Fluorine reacts with bromine to form liquid bromine trifluoride (BrF_3).

State the type of bond between Br and F in BrF_3 and state how this bond is formed.

Type of bond: .....

How bond is formed : .....

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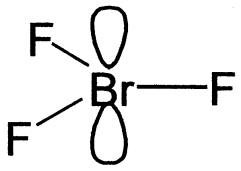
(2 marks)

(b) Two molecules of BrF_3 react to form ions as shown by the following equation.

$$2BrF_3 \longrightarrow BrF_2^+ + BrF_4^-$$

The shape of BrF_3 is given where the lobes represent lone pairs of electrons.



(i) Suggest the shape of BrF_3.

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(ii) Predict its bond angle.

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(c) BrF_4^- ions are also formed when potassium fluoride dissolves in liquid BrF_3 to form $KBrF_4$. Explain, in terms of bonding, why $KBrF_4$ has a high melting point. (3 marks)

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(d) Fluorine reacts with hydrogen to form hydrogen fluoride (HF).

(i) State the strongest type of intermolecular force between hydrogen fluoride molecules. (1 mark)

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(ii) Draw a diagram to show how two molecules of hydrogen fluoride are attracted to each other by the type of intermolecular force that you stated in part (d) (i).

Include all partial charges and all lone pairs of electrons in your diagram.

(3 marks)

(e) The boiling points of fluorine and hydrogen fluoride are –188°C and 19.5°C respectively. Explain, in terms of bonding, why the boiling point of fluorine is very low. (2 marks)

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14. The metal lead reacts with warm dilute nitric acid to produce lead (II) nitrate, nitrogen monoxide and water according to the following equation.

$$3Pb(s) + 8HNO_3(aq) \longrightarrow 3Pb(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$$

(a) In an experiment, an 8.14 g sample of lead reacted completely with a 2.00 mol dm^{-3} solution of nitric acid. Calculate the volume of nitric acid required for complete reaction. (3 marks)

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(b) (i) Determine the number of moles of NO(g) expected to be produced from the reaction of 8.14 g sample of lead in (a). (1 mark)

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(ii) The nitrogen monoxide gas produced in the reaction occupied 638 cm^3 at 101 kPa and 25°C. The vapour pressure of water vapour at 25°C is 7.31 kPa. Calculate the amount, in moles, of NO gas produced. Hence determine the percentage yield of the reaction. (4 marks)

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15. (a) The following table shows the boiling points of some straight-chain alkanes.

	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}
Boiling point / °C	–162	–88	–42	–1	36

Explain the trend in the boiling points of these straight-chain alkanes. (3 marks)

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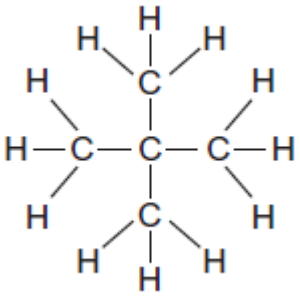
(b) The following compound X is an isomer of one of the alkanes in the table.



$CH_3C(CH_3)_2CH_3$

(i) Give the IUPAC name of X. (1 mark)

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(ii) X has a boiling point of 9.5 ºC.
Explain why the boiling point of X is lower than that of its straight-chain isomer.
(2 marks)

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(iii) The following compound Y is produced when X reacts with chlorine.

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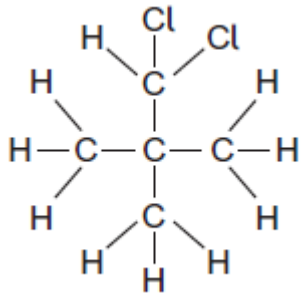	

In the space provided, draw the other position isomer/s of Y that can be formed.
(2 marks)

Describe and explain the trend in the boiling points of these position isomers of Y.
(3 marks)

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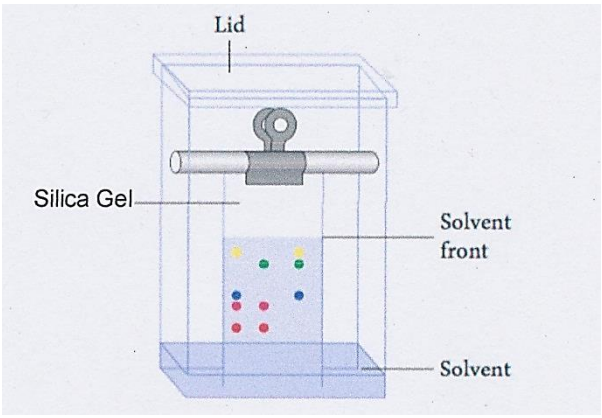
16. The following diagram shows a chromatography technique.



(a) Chromatography separates components of a mixture.

Explain the basic principals involved.
(3 marks)

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(b) What is the name of the chromatography technique shown in the diagram above? Give an example of the type of molecule which is suitable for this type of chromatography. (2 marks)

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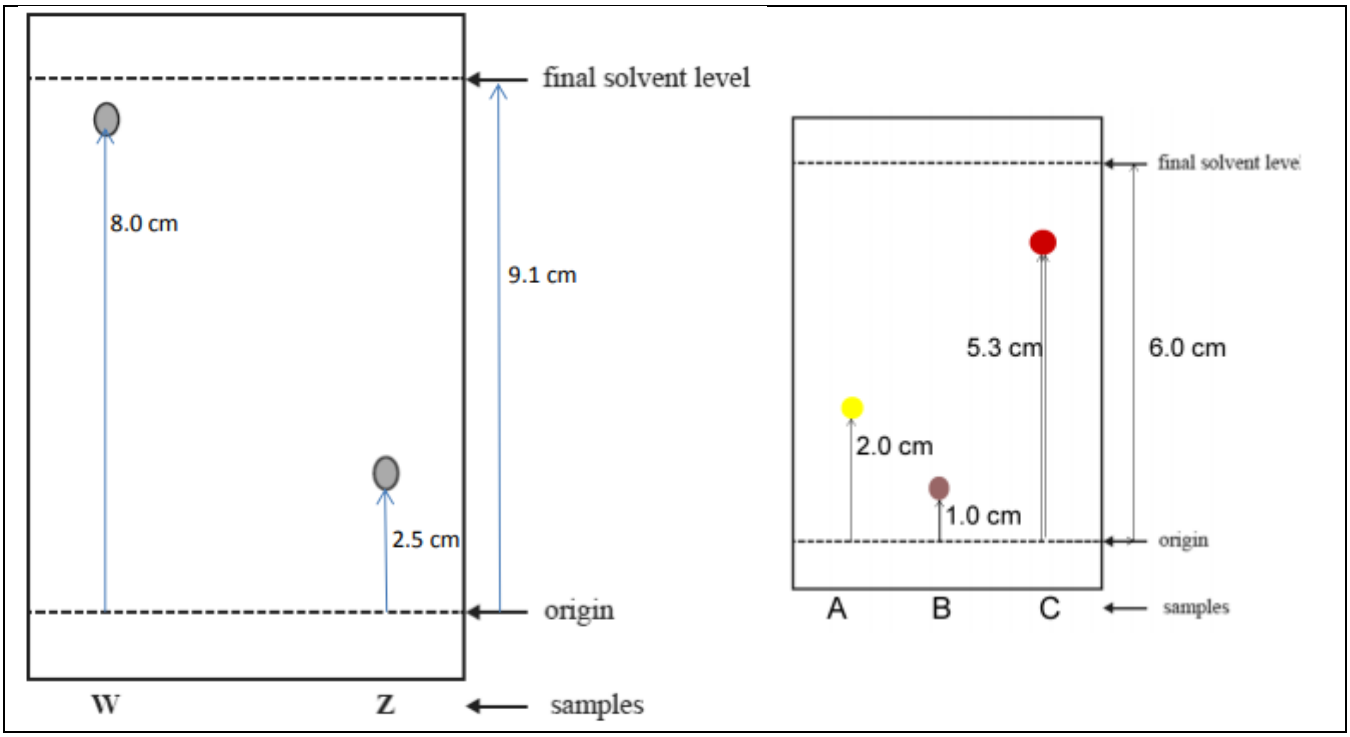
(c) Two different food dye samples, W and Z were compared using thin layer chromatography as shown below.



(iii) Calculate the R_f value of W and Z (3 marks)

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(ii) Which dye, W or Z, is more strongly adsorbed? (1 mark)

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(iii) Explain how dyes W and Z can be identified? (2 marks)

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(iv) On the right is another chromatogram of a food substance containing food dye. Is dye "W" present? Explain. (3 marks)

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(d) What is the difference in R_f and R_t? Where would R_t be used? (2 marks)

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17. Consider the following Figure 1. It shows the standard retention time for a set of various substances passed through a gas chromatography process.

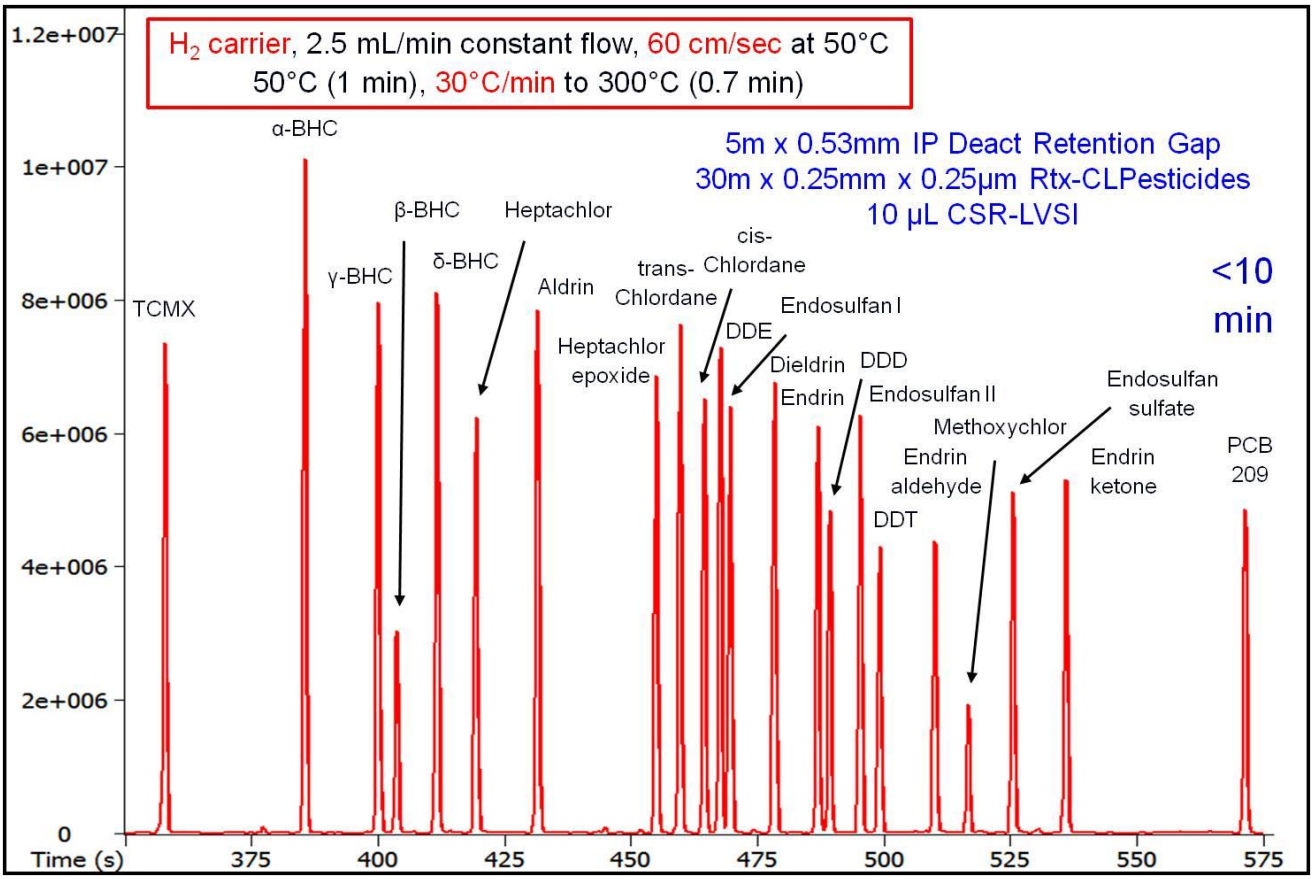

Figure 1

The following Figure 2 shows the gas chromatograph of a tested sample.

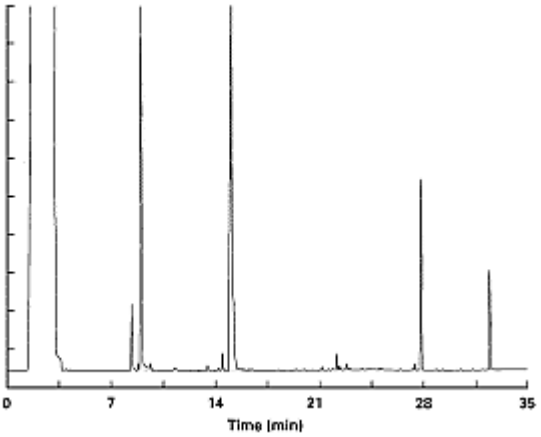

Figure 2

(a) Use Figures 1 and 2 to identify one substance in the sample. Show your working clearly. (3 marks)

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(b) The following Figure 3 shows the Calibration curve of absorbance vs concentration for the substance found in (a).

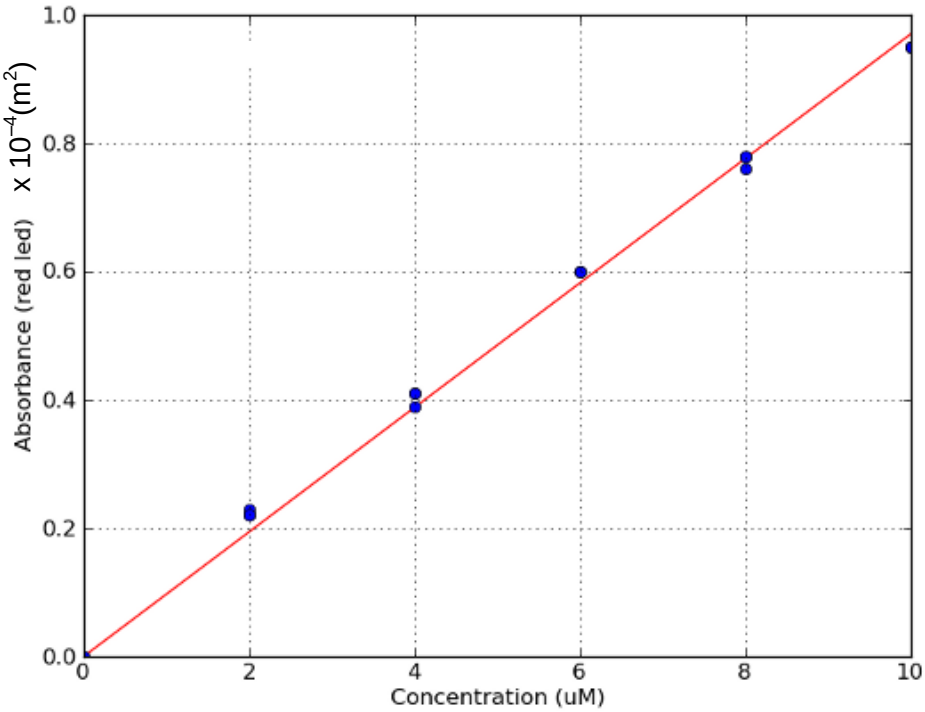

Figure 3

The following Figure 4 shows the enlarged and measured peak of the substance found in (a)

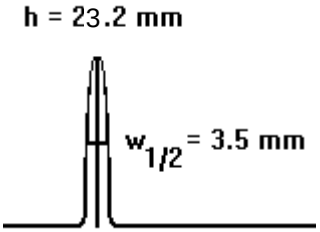

Figure 4

Use Figures 3 and 4 to determine the concentration of the substance in the sample. Show your working clearly. (3 marks)

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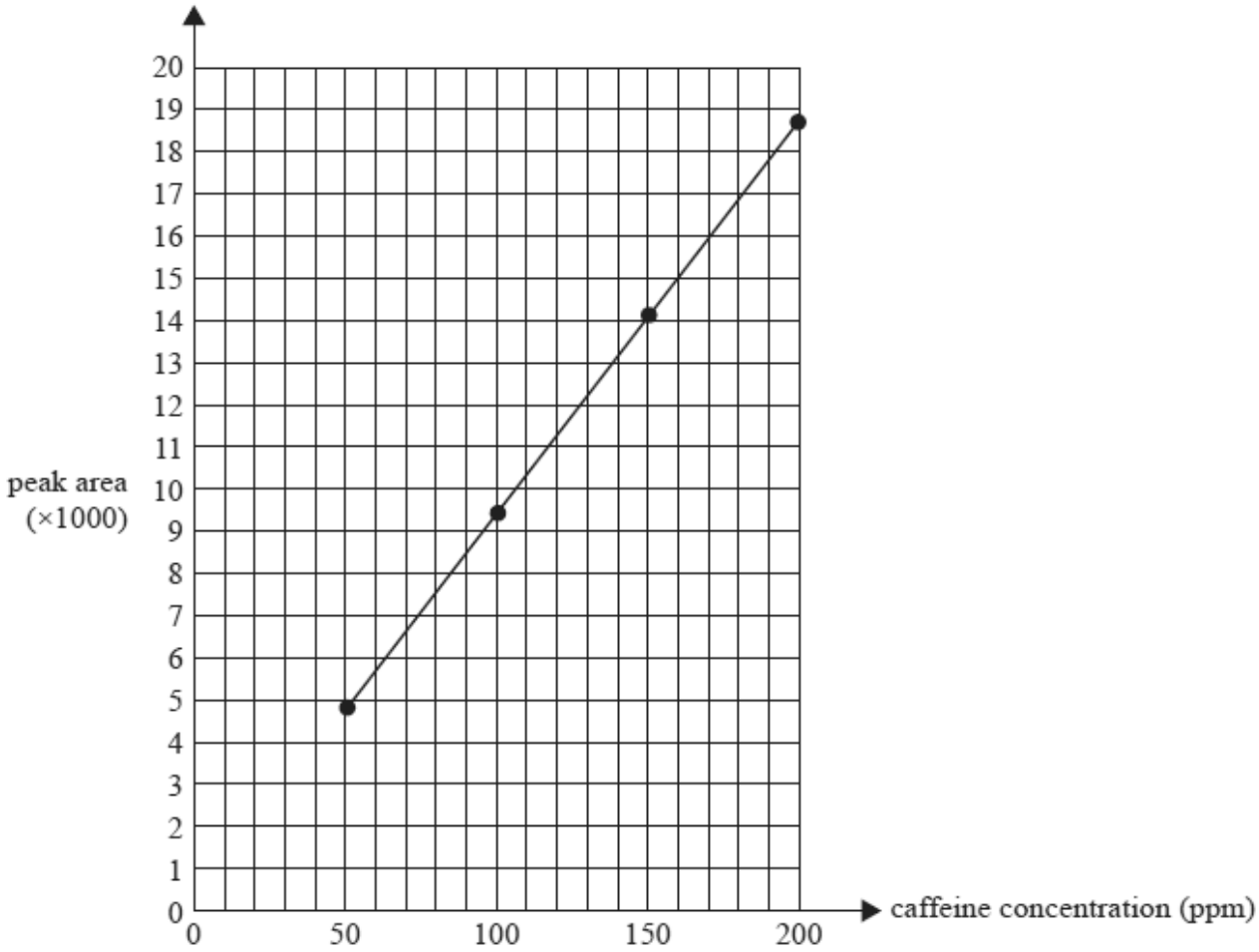
18. Caffeine is a stimulant drug that is found in coffee, tea, energy drinks and some soft drinks. The concentration of caffeine can be determined using HPLC. Four caffeine solutions containing 50 ppm, 100 ppm, 150 ppm and 200 ppm were prepared. 25 microliters of each sample was injected into the HPLC column. The peak areas were measured and used to construct the calibration graph below. The chromatograms of the standard solution each produced a single peak at a retention time of 96 seconds.

Graph: Peak area of caffeine standard solutions: retention time = 96 seconds



25 micro-litre samples of various drinks thought to contain caffeine were then separately passed through the HPLC column. The results are shown below.

Sample	Retention time of major peak (seconds)	Peak area of largest peak
Soft drink A	96	12 000
Soft drink B	32	8 500
Espresso coffee	96	211 000

(a) Determine the caffeine content in ppm for drink A. (1 mark)

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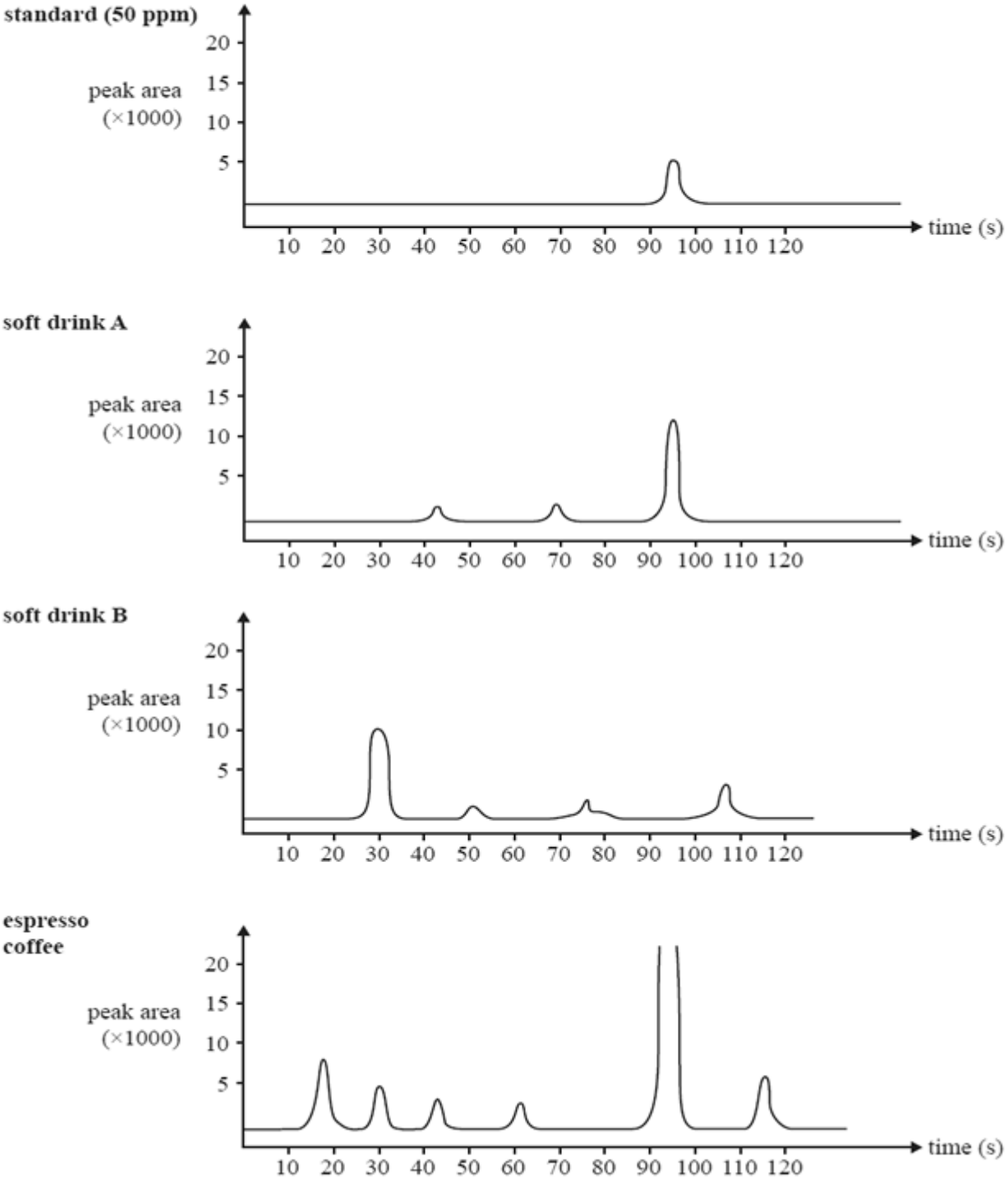
The chromatographs of the various drinks thought to contain caffeine are shown below.

Chromatograms of 50 ppm standard caffeine solution, soft drink A, soft drink B and espresso coffee



(b) What evidence is presented in the chromatogram that supports the conclusion that soft drink B does not contain any caffeine? (2 marks)

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(c) Explain why the caffeine content of the espresso coffee sample cannot be reliably determined using the information provided. (2 marks)

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(d) Describe what can be done to the espresso coffee sample so that its caffeine content can be reliably determined using the information provided. (2 marks)

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