IB · DP · Chemistry

2 hours 14 questions

Structured Questions: Paper 2

1.1 Matter, Chemical Change & the Mole Concept

1.1.1 Elements, Compounds & Mixtures / 1.1.2 Equations / 1.1.3 State Changes / 1.1.4 The Mole Concept / 1.1.5 Moles-Mass Problems / 1.1.6 Empirical Formulae

Easy (5 questions)	/27
Medium (4 questions)	/35
Hard (5 questions)	/37
Total Marks	**/99**

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Easy Questions

1 (a) Urea, $CO(NH_2)_2$, is an animal waste product that can be used as a fertiliser. It can also be made artificially by reacting ammonia, NH_3, with carbon dioxide, CO_2, forming water as a co-product.

Formulate a balanced equation for the reaction.

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(1 mark)

(b) Calculate the molar mass of urea, $CO(NH_2)_2$.

.....

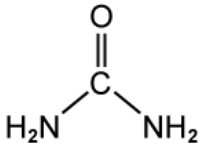
(1 mark)

(c) Calculate the percentage of nitrogen in urea. Give your answer to two decimal places.

.....

(1 mark)

(d) The chemical structure of urea is shown below:



Deduce the total number of electron pairs in the molecule.

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(1 mark)

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2 (a) Name the six changes of state, and state which changes are accompanied by a decrease in particle separation distances.

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.....

(2 marks)

(b) State the difference between a *homogeneous* and a *heterogeneous* mixture.

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(1 mark)

(c) Classify the following mixtures as *homogeneous* or *heterogeneous*: crude oil, concrete and brass.

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(3 marks)

(d) Which technique would be the most suitable for the separation of crude oil?

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(1 mark)

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3 (a) A compound with M_r =104.07 contains 34.62 % carbon, 3.88 % hydrogen and 61.50 % oxygen by mass.

Calculate its empirical formula.

(4 marks)

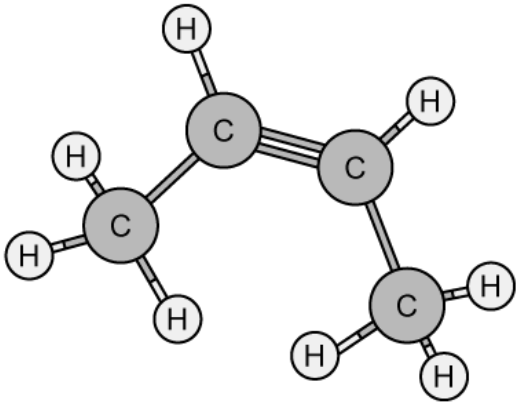
(b) Calculate the molecular formula of the compound in part a).

(1 mark)

Draw a possible structure for the compound in part b).

(c) **(1 mark)**

(d) Deduce the empirical formula of the following molecule:



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(1 mark)

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4 (a) State the meaning of the term empirical formula.

.....

(1 mark)

(b) An unknown compound contains carbon, hydrogen and oxygen only. It was shown to contain 3.20 g carbon, 0.54 g hydrogen and 4.26 g oxygen.

Calculate the empirical formula of the unknown compound.

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(3 marks)

(c) Determine the molecular formula of the compound in part b), given the M_r = 90.09.

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(1 mark)

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5 (a) Define the term *one mole* in chemistry.

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(1 mark)

(b) How many atoms are present in 0.200 mol of P_2O_5?

.....

(1 mark)

(c) How many moles are in 2.35 x 10^{24} molecules of oxygen gas?

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(1 mark)

(d) How many atoms are in 4.00 g of hydrogen gas?

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(1 mark)

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Medium Questions

1 (a) Mercury forms two oxides, mercury(I) oxide and mercury(II) oxide, which decompose into their elements when heated above 500°C.

After heating a 4.513 g sample of an oxide of mercury, 4.180 g of mercury was left. Determine the empirical formula of this oxide.

(4 marks)

(b) Formulate two equations, including state symbols, to show the decomposition of the two oxides of mercury.

(2 marks)

(c) Another sample of the same mass of mercury oxide in part (a) was heated and gave a **lower** mass of mercury. Suggest why less mercury could have been obtained.

(1 mark)

(d) Suggest why repeating the decomposition of the sample of mercury oxide in part (a) may give a **higher** mass of mercury than was obtained in part (a).

(1 mark)

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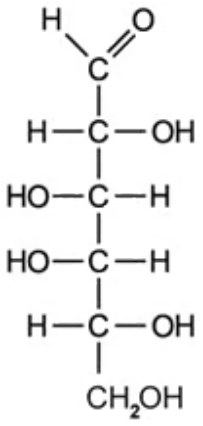
2 (a) The open-chain structure of the sugar galactose is shown in **Figure 1** below.

Figure 1



Determine the empirical formula of galactose.

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(1 mark)

(b) Calculate the percentage composition by mass of galactose.

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(3 marks)

(c) Formulate the balanced equation for the complete combustion of galactose.

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(2 marks)

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(d) Lactose, $C_{12}H_{22}O_{11}$, is a disaccharide sugar made from galactose and glucose unit joined together. A number of people suffer from lactose intolerance in their diet and research shows that the vast majority of sufferers can tolerate up to 12 g with few symptoms.

How many molecules of lactose is enough to cause symptoms?

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(3 marks)

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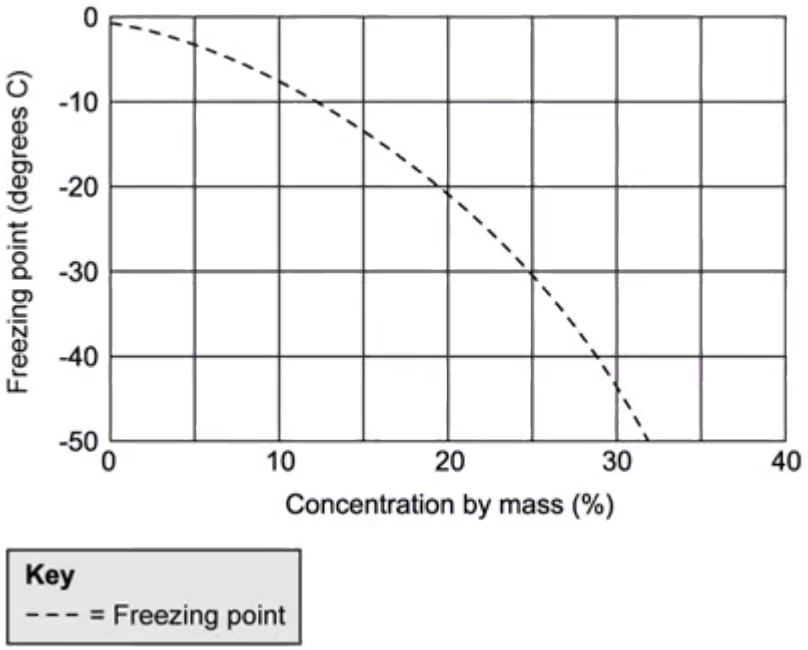
3 (a) Common salt, or sodium chloride, can be used on icy roads in the winter to lower the freezing point of water. However, there is a limitation to using it, as the lowest freezing point that can be reached using sodium chloride is about -21 ^{o}C at 23% by mass of sodium chloride.

Other salts such as calcium chloride can also be used for this purpose. **Figure 1** below shows a freezing point graph for calcium chloride/water.

Estimate the freezing point of water when the composition is 23% by mass of calcium chloride.

Figure 1



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(1 mark)

(b) What % mass of calcium chloride would be needed to lower the freezing point of water in a 5-litre bucket to -30 ^{o}C and what would be the density of the resulting solution?

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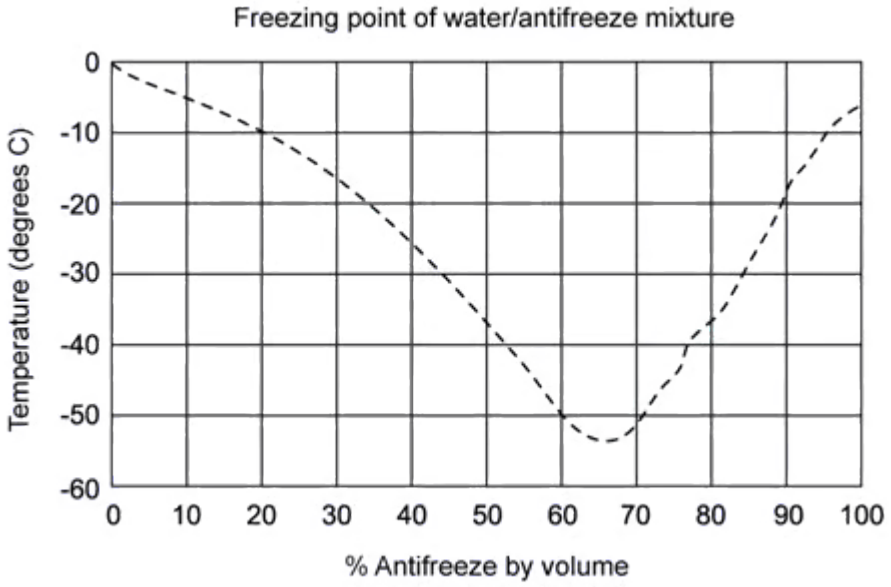
(3 marks)

(c) Antifreeze is a chemical largely consisting of ethylene glycol, $C_2H_6O_2$, which also lowers the freezing point of water and is used in car cooling systems. **Figure 2** shows the freezing point graph for a water/antifreeze mixture.

Figure 2



If a car cooling system holds 5 litres of water, what is the minimum number of molecules of ethylene glycol needed to lower the freezing point to -50 ^{o}C?

The density of ethylene glycol is 1.11 gcm^{-3}.

(4 marks)

(d) Suggest one reason why is it better to use ethylene glycol in a car's cooling system rather than calcium chloride.

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(1 mark)

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4 (a) Camphor is a waxy, flammable, transparent solid with a strong aroma. It contains only carbon, hydrogen, and oxygen. It is found in the wood of the camphor laurel, a large evergreen tree found in East Asia.

Combustion analysis of camphor showed that a 2.450 g sample of camphor when burned in excess oxygen, produced 7.081 g of carbon dioxide and 2.320 g of water. Deduce the empirical formula of camphor.

(5 marks)

(b) Deduce the molecular formula of camphor (M = 152.23 $gmol^{-1}$).

(1 mark)

(c) Formulate a balanced equation, including state symbols, for the complete combustion of camphor.

(2 marks)

(d) Calculate the number of molecules in a teaspoon of camphor. The teaspoon holds 5.0 g of camphor (M = 152.23 $gmol^{-1}$).

(1 mark)

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Hard Questions

1 (a) Nitroglycerin is an oily, colourless liquid and a high explosive, discovered by Alfred Nobel. The unbalanced equation for its explosive decomposition is given below.

$$\ldots\ldots C_3H_5N_3O_9\,(l) \rightarrow \ldots\ldots N_2\,(g) + \ldots\ldots CO\,(g) + \ldots\ldots H_2O\,(g) + \ldots\ldots O_2\,(g)$$

Deduce the coefficients required to balance the equation for this reaction and use the equation to suggest why nitroglycerin acts as a high explosive.

(2 marks)

(b) Nitroglycerin is also used medicinally to treat angina attacks. It comes in the form of tablets, ointments, skin patches and nasal sprays. Nasal sprays vaporise the nitroglycerin, so it is quickly absorbed in the body.

A commercial 11.2 g nasal spray pump delivers a metered dose of exactly 400 micrograms of nitroglycerin. Determine the number of moles present in one dose and how many doses a spray pump can deliver.

(4 marks)

(c) Suggest a reason why the actual number of doses delivered by the spray pump is less than you have calculated in (b).

(1 mark)

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Describe the changes of state and the energy changes that take place when the spray pump is used.

(d) .....

(1 mark)

2 (a) Carvone is an organic compound containing carbon hydrogen and oxygen.

Complete combustion of 0.1526 g carvone produces 0.4470 g of carbon dioxide and 0.1281 g of water. Determine the empirical formula of carvone, showing your working.

(3 marks)

(b) 0.146 g sample of carvone, when vaporised, had a volume of 0.0341 dm^3 at 150 ^oC and 100.2 kPa. Calculate its molar mass showing your working.

(2 marks)

(c) Using your answer to part b), determine the number of molecules of carvone in 0.146 g.

(2 marks)

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Calculate the number of atoms of nitrogen in 38.46 g of ammonium sulfate?

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3 (a) **(2 marks)**

Deduce the number of protons in 38.46 g of ammonium sulfate.

.....

.....

(b) **(2 marks)**

(c) Using Section 4 of the Data booklet, calculate the mass, in g, of protons in 38.46 g of ammonium sulfate.

.....

(1 mark)

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4 (a) The coca cola company states that a 12 oz can of coke contains 34 mg of caffeine, M = 194.19 g mol^{-1}. Calculate the number of moles of caffeine in a can of coke.

(1 mark)

(b) The composition by mass of caffeine is 49.48% carbon, 5.20% hydrogen, 28.85% nitrogen and the rest is oxygen. Calculate the empirical formula of caffeine.

(4 marks)

(c) Calculate the molecular formula of caffeine using your answer from part b).

(1 mark)

(d) State the type of mixture coca cola is.
Does this change after the can of coke is opened? Justify your answer.

(2 marks)

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5 (a) Concentrated nitric acid can be made to react with sulfur, and will produce sulfuric acid, nitrogen dioxide and water as the only products. Write a balanced equation for the reaction.

(1 mark)

(b) Deduce the redox changes taking place in the reaction in part a).

(2 marks)

(c) Examine the state changes in the reaction in part a) and suggest the relative difference in the energy content of the products and reactants.

(2 marks)

(d) Identify the ions in part a) and calculate the sum of the relative formula masses of *all* the ions in reaction equation, using section 6 of the Data booklet.

(4 marks)

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