1.1 Matter, Chemical Change & the Mole Concept

Question Paper

Course	DP IB Chemistry
Section	1. Stoichiometric Relationships
Topic	1.1 Matter, Chemical Change & the Mole Concept
Difficulty	Medium

Time allowed: 50

Score: /35

Percentage: /100

Question 1a

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]

Question 1b

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

[2 marks]

Question 1c

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]

Question 1d

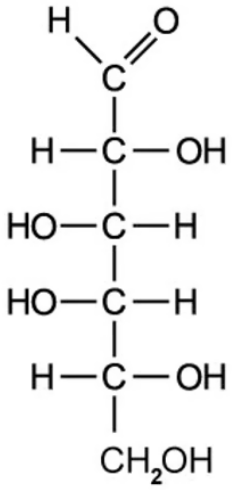
d) Suggest why repeating the decomposition of the sample of mercury oxide in part (a) may give a **higher** mass of mercury than was obtained in part (a)

[1 mark]

Question 2a

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

Figure 1



Determine the empirical formula of galactose.

[1 mark]

Question 2b

b) Calculate the percentage composition by mass of galactose.

[3 marks]

Question 2c

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

[2 marks]

Question 2d

d) Lactose, $C_{12}H_{22}O_{11}$, is a disaccharide sugar made from galactose and glucose units 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?

[3 marks]

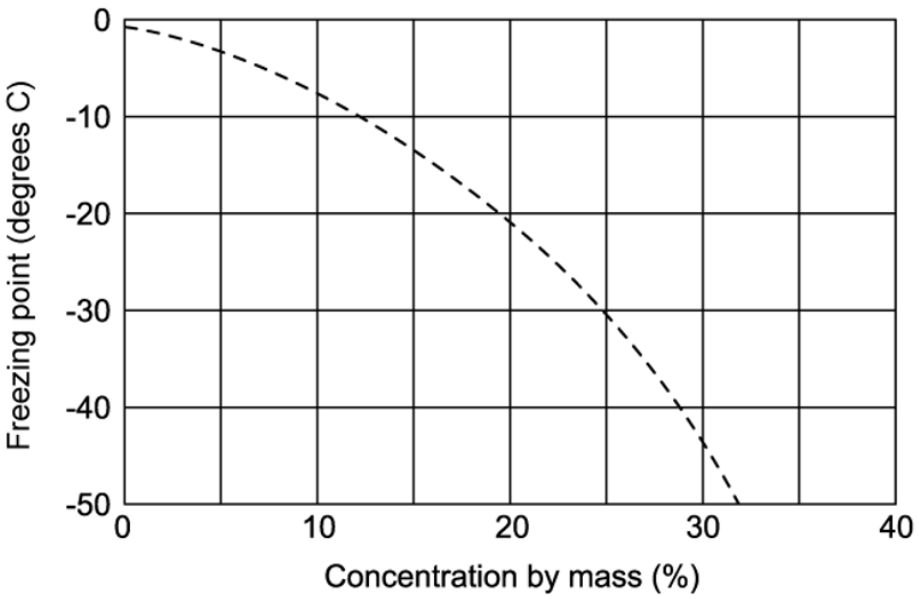
Question 3a

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°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



[1 mark]

Question 3b

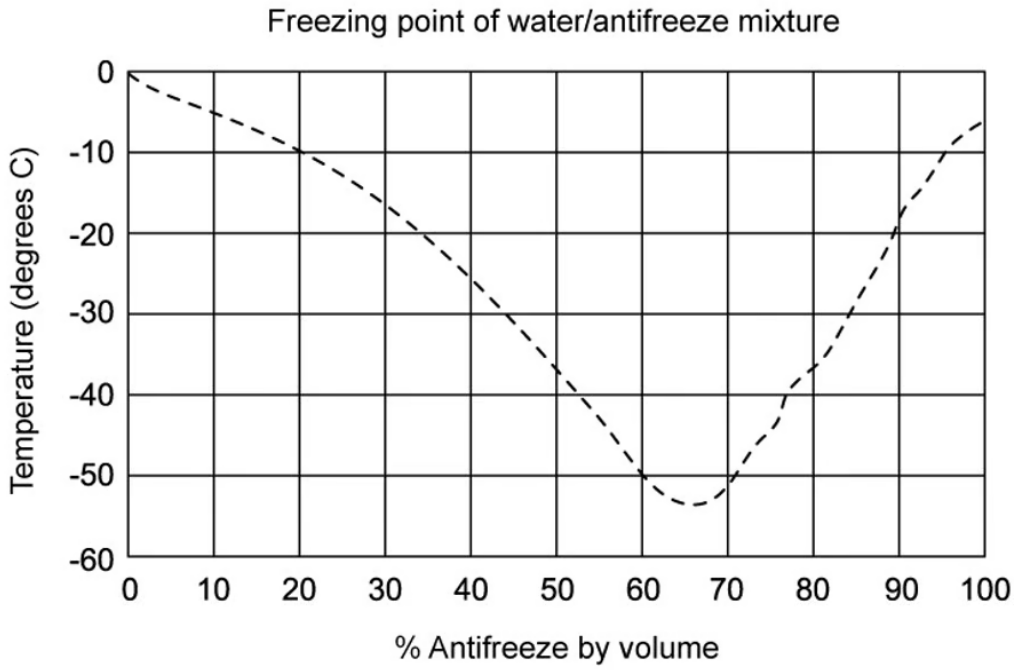
b) What % mass of calcium chloride would be needed to lower the freezing point of water in a 5-litre bucket to -30°C and what would be the density of the resulting solution?

[3 marks]

Question 3c

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 °C?

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

[4 marks]

Question 3d

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

[1 mark]

Question 4a

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]

Question 4b

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

[1 mark]

Question 4c

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

[2 marks]

Question 4d

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

[1 mark]