1978

The freezing point and electrical conductivities of three aqueous solutions are given below.

Solution (0.010 molal)	Freezing Point	Electrical Conductivity
sucrose	−0.0186°C	almost zero
formic acid	−0.0213°C	low
sodium formate	−0.0361°C	high

Explain the relationship between the freezing point and electrical conductivity for each of the solutions above. Account for the differences in the freezing points among the three solutions.

1980

(a) A solution containing 3.23 grams of an unknown compound dissolved in 100.0 grams of water freezes at −0.97°C. The solution does not conduct electricity. Calculate the molecular weight of the compound. (The molal freezing point depression constant for water is 1.86°C kg $mole^{-1}$)

(b) Elemental analysis of this unknown compound yields the following percentages by weight H = 9.74%; C = 38.70%; O = 51.56%. Determine the molecular formula for the compound.

(c) Complete combustion of a 1.05 gram sample of the compound with the stoichiometric amount of oxygen gas produces a mixture of $H_2O(g)$ and $CO_2(g)$. What is the pressure of this gas mixture when it is contained in a 3.00 liter flask at 127°C?

1985

The formula and the molecular weight of an unknown hydrocarbon compound are to be determined by elemental analysis and the freezing-point depression method.

(a) The hydrocarbon is found to contain 93.46 percent carbon and 6.54 percent hydrogen. Calculate the empirical formula of the unknown hydrocarbon.

(b) A solution is prepared by dissolving 2.53 grams of p-dichlorobenzene (molecular weight 147.0) in 25.86 grams of naphthalene (molecular weight 128.2). Calculate the molality of the p-dichlorobenzene solution.

(c) The freezing point of pure naphthalene is determined to be 80.2°C. The solution prepared in (b) is found to have an initial freezing point of 75.7°C. Calculate the molal freezing-point depression constant of naphthalene.

(d) A solution of 2.42 grams of the unknown hydrocarbon dissolved in 26.7 grams of naphthalene is found to freeze initially at 76.2°C. Calculate the apparent molecular weight of the unknown hydrocarbon on the basis of the freezing-point depression experiment above.

(e) What is the molecular formula of the unknown hydrocarbon?

1988

The normal boiling and freezing points of argon are 87.3 K and 84.0 K, respectively. The triple point is at 82.7 K and 0.68 atmosphere.

(a) Use the data above to draw a phase diagram for argon. Label the axes and label the regions in which the solid, liquid and gas phases are stable. On the phase diagram, show the position of the normal boiling point.

(b) Describe any changes that can be observed in a sample of solid argon when the temperature is increased from 40 K to 160 K at a constant pressure of 0.50 atmosphere.

(c) Describe any changes that can be observed in a sample of liquid argon when the pressure is reduced from 10 atmospheres to 1 atmosphere at a constant temperature of 100 K, which is well below the critical temperature.

(d) Does the liquid phase of argon have a density greater than, equal to, or less than the density of the solid phase? Explain your answer, using information given in the introduction to this question.

1995

Propane, C_3H_8, is a hydrocarbon that is commonly used as fuel for cooking.

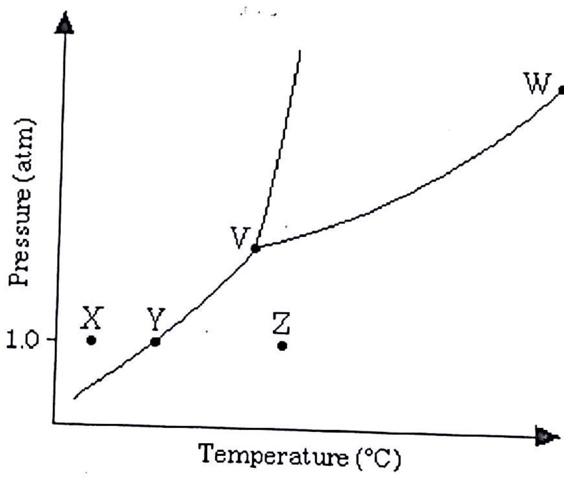
(a) Write a balanced equation for the complete combustion of propane gas, which yields $CO_2(g)$ and $H_2O(l)$.

(b) Calculate the volume of air at 30°C and 1.00 atmosphere that is needed to burn completely 10.0 grams of propane. Assume that air is 21.0 percent O_2 by volume.

(c) The heat of combustion of propane is -2,220.1 kJ/mol. Calculate the heat of formation, ΔH_f° of propane given that ΔH_f° of $H_2O(l) = -285.3$ kJ/mol and ΔH_f° of $CO_2(g) = -393.5$ kJ/mol.

(d) Assuming that all of the heat evolved in burning 30.0 grams of propane is transferred to 8.00 kilograms of water (specific heat = 4.18 J/g·K), calculate the increase in temperature of water.

1995



The phase diagram for a pure substance is shown above. Use this diagram and your knowledge about changes of phase to answer the following questions.

(a) What does point *V* represent? What characteristics are specific to the system only at point *V*?

(b) What does each point on the curve between *V* and *W* represent?

(c) Describe the changes that the system undergoes as the temperature slowly increases from *X* to *Y* to *Z* at 1.0 atmosphere.

(d) In a solid-liquid mixture of this substance, will the solid float or sink? Explain.

1998

$$C_6H_5OH(s) + 7\ O_2(g) \rightarrow 6\ CO_2(g) + 3\ H_2O(l)$$

When a 2.000-gram sample of pure phenol, $C_6H_5OH(s)$, is completely burned according to the equation above, 64.98 kilojoules of heat is released. Use the information in the table below to answer the questions that follow.

Substance	Standard Heat of Formation, $\Delta H°_f$, at 25°C (kJ/mol)	~~Absolute Entropy, $S°$, at 25°C (J/mol-K)~~
$C_{(graphite)}$	0.00	5.69
$CO_2(g)$	−393.5	213.6
$H_2(g)$	0.00	130.6
$H_2O(l)$	−285.85	69.91
$O_2(g)$	0.00	205.0
$C_6H_5OH(s)$	?	144.0

(a) Calculate the molar heat of combustion of phenol in kilojoules per mole at 25°C.

(b) Calculate the standard heat of formation, $\Delta H°_f$, of phenol in kilojoules per mole at 25°C.

~~(c) Calculate the value of the standard free-energy change, $\Delta G°$ for the combustion of phenol at 25°C.~~

(d) If the volume of the combustion container is 10.0 liters, calculate the final pressure in the container when the temperature is changed to 110°C. (Assume no oxygen remains unreacted and that all products are gaseous.)

2003B

In an experiment, a sample of an unknown, pure gaseous hydrocarbon was analyzed. Results showed that the sample contained 6.000 g of carbon and 1.344 g of hydrogen.

(a) Determine the empirical formula of the hydrocarbon.

(b) The density of the hydrocarbon at 25°C and 1.09 atm is 1.96 g L^{-1}.

  (i) Calculate the molar mass of the hydrocarbon.

  (ii) Determine the molecular formula of the hydrocarbon.

In another experiment, liquid heptane, $C_7H_{16}(l)$, is completely combusted to produce $CO_2(g)$ and $H_2O(l)$, as represented by the following equation.

$$C_7H_{16}(l) + 11\ O_2(g) \rightarrow 7\ CO_2(g) + 8\ H_2O(l)$$

The heat of combustion, $\Delta H°_{comb}$, for one mole of $C_7H_{16}(l)$ is -4.85×10^3 kJ.

(c) Using the information in the table below, calculate the value of $\Delta H°_f$ for $C_7H_{16}(l)$ in kJ mol^{-1}.

Compound	ΔH_f° (kJ mol^{-1})
$CO_2(g)$	−393.5
$H_2O(l)$	−285.8

(d) A 0.0108 mol sample of $C_7H_{16}(l)$ is combusted in a bomb calorimeter.

  (i) Calculate the amount of heat released to the calorimeter.

  (ii) Given that the total heat capacity of the calorimeter is 9.273 kJ $°C^{-1}$, calculate the temperature change of the calorimeter.