Chemistry Enhancement Course 2004/5
Mathematics for Chemistry

Answer all four short questions and one long question.

Short Questions

1. Rearrange the following equations to make y the subject:

   (a) $x - y = 7$
   (b) $3x + 9y = 12$
   (c) $4xy = 1$
   (d) $x^2 - y = 2$
   (e) $x^2 + y^2 = 9$

   (10 marks)

2. A function $f(x,y)$ is defined by the equation

   $$f(x,y) = 2x - 4y$$

   Evaluate

   (a) $f(0,0)$
   (b) $f(1,1)$
   (c) $f(3,1)$
   (d) $f(3,-1)$
   (e) $f(-1,-3)$

   (10 marks)

3. For the following relationships, state what type of plot would give a straight line and the value of the resulting gradient and intercept:

   (a) $y = 4x - 8$
   (b) $y = 3x^2 + 2$
   (c) $y = 5 \ln x - 6$
   (d) $y^2 = 5x^2 - 7$
   (e) $\ln y = \ln x^2 + 1$

   (10 marks)

4. The Nernst equation gives the electromotive force (EMF) E of an electrochemical cell as a function of the absolute temperature T as

$$E = E^o - \frac{RT}{nF} \ln Q$$

where E^o is the EMF of the cell under standard conditions, R is the gas constant, n the amount of charge transferred , F the Faraday and Q the reaction constant. Determine the value of Q when E = -0.025 V, E^o = 0.030 V, R = 8.314 J K^{-1} mol^{-1}, T = 295 K, n = 2 and F = 96 485 C mol^{-1}. Note that 1 V = 1 J C^{-1}.

(10 marks)

Long Questions

5. (a) Convert 1.61 a_o to nm, given that 1 a_o = 5.292 x 10^{-11} m and 1 nm = 10^{-9} m. Give your answer to an appropriate number of figures.

(6 marks)

(b) The pressure *p* of an ideal gas is given by

$$p = \frac{nRT}{V}$$

where *n* is the amount of gas, *T* its absolute temperature, and *V* the volume. *R* is the gas constant. Calculate the pressure, quoted to an appropriate degree of precision, of 1.48 moles of an ideal gas at 302 K having a volume of 0.1534 m^3. Take *R* as 8.31 J K^{-1} mol^{-1}.

(8 marks)

(c) A voltmeter measures the EMF of an electrochemical cell to the nearest 0.1 V. Assuming an uncertainty of ±0.05 V on a reading of 5.95 V, give the absolute error, the fractional error and the percentage error on this reading.

(6 marks)

6. (a) Evaluate the following and express in their simplest fractional form:

(i) $\frac{2}{3}+\frac{3}{4}$ (ii) $\frac{7}{8}-\frac{4}{5}$

(5 marks)

(b) Evaluate the following and express in their simplest fractional form:

(i) $\frac{2}{5}\times\frac{3}{8}$ (ii) $\frac{3}{5}\div\frac{5}{9}$

(5 marks)

(c) The wavenumbers $\bar{\nu}$ of lines in the spectrum of the hydrogen atom are given by the equation

$$\bar{\nu} = R\left(\frac{1}{m^2}-\frac{1}{n^2}\right)$$

where *R* is the Rydberg constant, *m* is an integer of value 1 or greater, and *n* is an integer whose value is greater than that of *m*. Obtain an expression for the wavelength λ which is equal to $1/\bar{\nu}$.

(10 marks)

Useful Relationships

$y = mx + c$

$\text{arc}(\ln x) = e^x$