CHM2330 Midterm Friday, Feb. 18th, 2011

Name: _____

Student #: _____

This is a closed book exam with no notes allowed. Calculators are permitted.
Write all the formulas that you use to solve the questions and show all your work.
Be sure to include units and the correct number of significant digits in your answer.

Constants and Data:

$R = 8.314\ \text{J K}^{-1}\ \text{mol}^{-1} = N_A * k$

$k = 1.381 \times 10^{-23}\ \text{J K}^{-1}$

$N_A = 6.023 \times 10^{23}\ \text{mol}^{-1}$

$h = 6.6261 \times 10^{-34}\ \text{J s}$

$c = 2.9979 \times 10^{8}\ \text{m s}^{-1}$

$1\ \text{m} = 100\ \text{cm} = 10^{9}\ \text{nm}$

$1\ \text{W} = 1\ \text{J s}^{-1}$

$1\ \text{J} = 1\ \text{kg m}^{2}\ \text{s}^{-2}$

$1\ \text{Pa} = 1\ \text{kg m}^{-1}\ \text{s}^{-1}$

$1\ \text{mol dm}^{-3} = 1\ \text{M} = 1000\ \text{mM}$

$1\ \text{atm} = 760\ \text{Torr} = 101325\ \text{Pa} = 1.01325\ \text{bar}$

$\sigma_{He} = 0.21\ \text{nm}^2$ $M_{He} = 4.00\ \text{g mol}^{-1}$

Formula sheet is on last page - this can be removed and does not have to be handed in.

Q1: _____/3 Q2: _____/2 Q2: _____/4 Q3: _____/12 Q4: _____/3

Q5: _____/4 Q6: _____/7

Total = _____/35

1) The following statements are FALSE. **Explain why they are false** in ~one sentence (3 marks):

a) The molecules in a gas at a lower temperature will have a broader distribution of speeds than the molecules in this same gas at a higher temperature.

b) According to Einstein's explanation of the photoelectric effect, the number of electrons lost and the speed at which they are ejected from a metal surface will depend on the number of photons that are absorbed by the surface.

2) For the reaction $A + 2B \rightarrow 3P$ the initial concentration of B is 0.22 mol dm^{-3}. What is the concentration of P at the point when 0.12 mol dm^{-3} of B has been consumed? (2 marks)

3) How many collisions does a single helium molecule make in one minute when the temperature is 25.0 ^{o}C and the pressure is 1.00 atm? (4 marks)

4) A reaction occurs through a series of elementary reactions:

$$A + B \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} I \xrightarrow{k_2} P$$

a) What is molecularity of the last step? (1 mark)

b) Write the expression for $\frac{d[I]}{dt}$ in terms of the microscopic rate constants of the elementary reactions. (2 marks)

c) What must be true about the relative speed of the elementary reactions in order to allow pre-equilibrium conditions to be assumed? (1 mark)

d) Briefly describe how the isolation method would be used to find the order of the reaction with respect to A. (3 marks)

e) If the activation energy for this reaction is 25 kJ mol^{-1}, how much must the temperature be raised to make the reaction go two times faster that it goes at 25^{o}C? (3 marks)

f) Suppose the last step is an intramolecular cyclization of the intermediate I to produce the product P. Will $\Delta S^{\ddagger}$ be greater than, less than or equal to zero for this step? Provide a one-sentence justification of your answer. (2 marks)

5. A typical microwave kitchen appliance emits 1000 W microwave radiation (12.2 cm wavelength). How many photons would this microwave emit each second? (3 marks)

6. a) Name one physical phenomenon that could not be described by classical mechanics. (1 mark)

b) What did classical mechanics predict for this phenomenon, and how did this differ from experimental observations? (2 marks)

c) What equation comes out of the quantum mechanical description of this phenomenon that solved this problem? (1 mark)

8. The ground state wavefunction for a particle confined to a one-dimensional box of length L is

$$\psi = \sqrt{\frac{2}{L}} \sin\left(\frac{\pi x}{L}\right)$$

a) Using the Hamiltonian operator for a one-dimensional system, find the energy of this particle. Assume that the potential energy is zero throughout the box. (4 marks)

b) If the length L of this box is 10.0 nm, what is the probability that this particle will be found between x=9.90 nm and 10.00 nm? (3 marks)