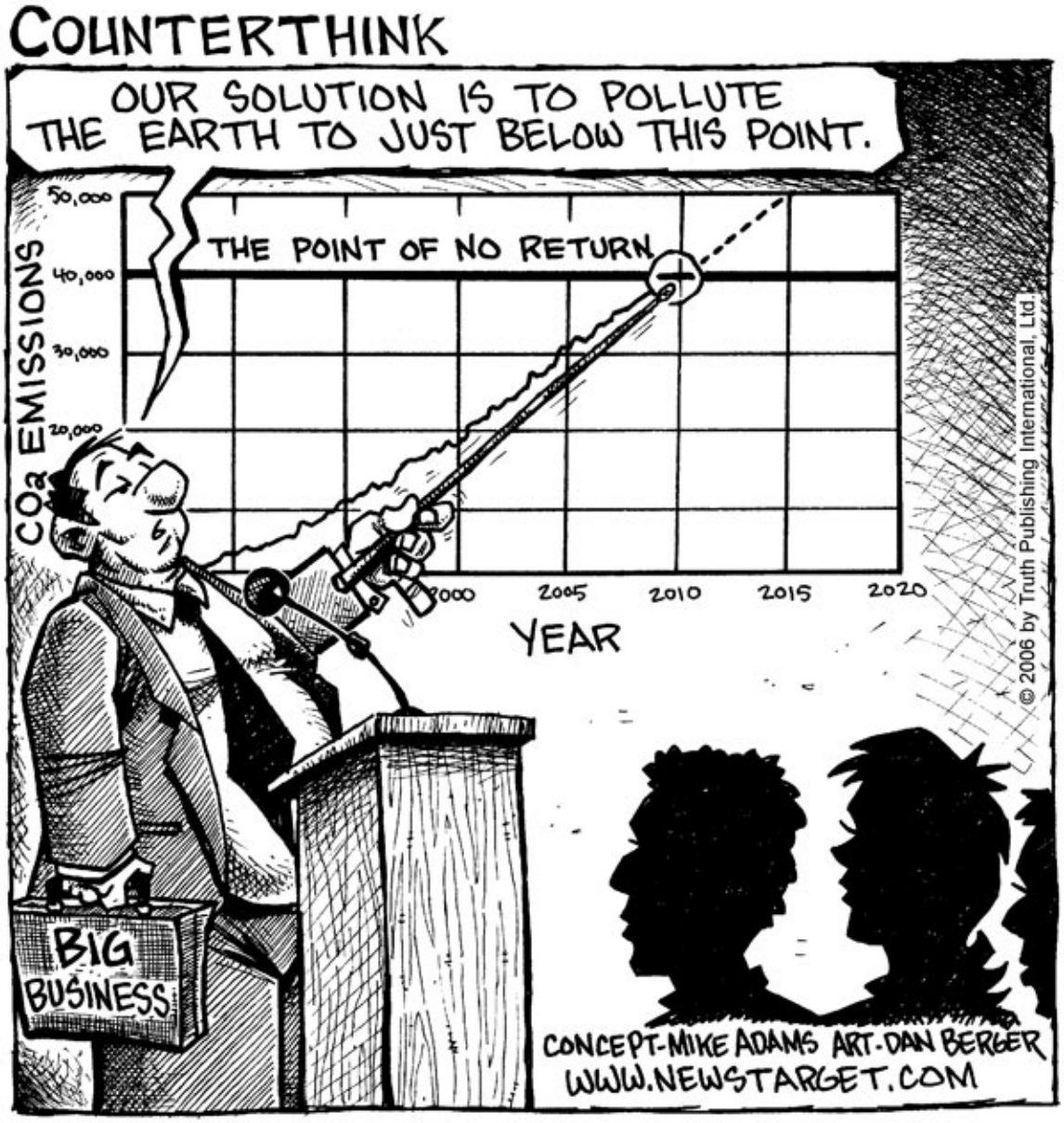
Chemistry 40S
Exam Review: Long Answer Questions

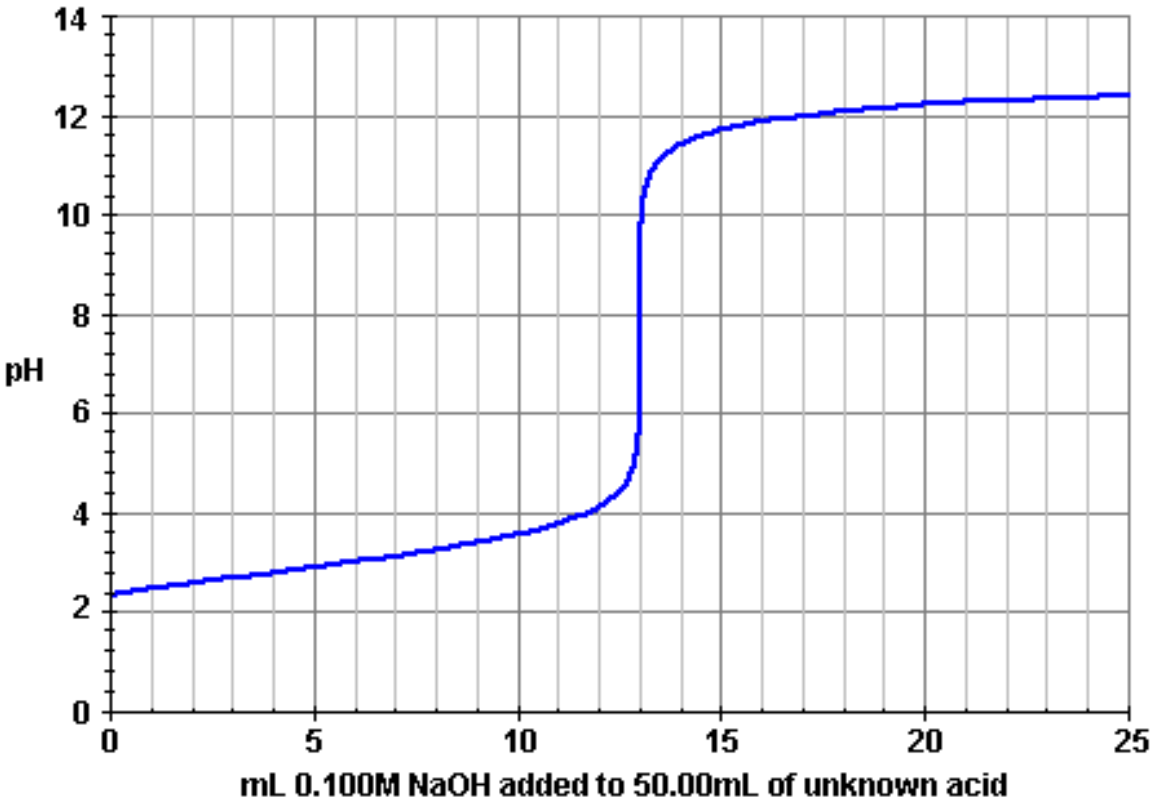


Aqueous Reactions

1. The neutralization of a 0.45 g sample of an unknown monoprotic acid required 30.00 mL of 0.15 mol/L LiOH. Calculate the molar mass of the acid.

2. Aqueous silver ions are added to a test tube containing an unknown ionic solution and a precipitate forms. Aqueous strontium 2+ is added to the same unknown solution, and no precipitate forms. With reference to your solubility chart, list the ion(s) that could be present in the unknown solution.

3. When a solution of 50 mL of an unknown weak monoprotic acid was titrated with 0.1 mol/L sodium hydroxide the following curve of pH versus volume was plotted. If 0.36 grams of the unknown acid was dissolved to make the 50 mL solution, what is the molar mass of the acid?



4. Consider the following unbalanced oxidation reduction reaction, which takes place in an acidic solution. Balance the reaction.

$$As + ClO_3^- \rightarrow H_3AsO_3 + HClO$$

5. The following oxidation reduction reaction occurs in acid solution:

$$4Zn(s) + 2NO_3^-(aq) + 10H^+(aq) \rightarrow 4Zn^{2+}(aq) + N_2O(g) + 5H_2O(l)$$

   a) Assign oxidation numbers

   b) Determine the species that is

      i) reduced.

      ii) oxidized.

      iii) the oxidizing agent.

      iv) the reducing agent.

Atomic Structure

6. Using your periodic table, and the first 18 elements, use the following information given to identify the elements in question.

   a) What is the most electronegative element?

   b) I am in the same family as N and have a larger radius.

   c) I have 5 protons in my nucleus.

   d) We are the three noble gases.
      i) I have the smallest atomic radius
      ii) I have the same electron configuration as Cl^-
      iii) I am the remaining noble gas

   e) I have the similar chemical properties as the element in part a, but I am not the lightest element.

   f) I am the lightest element.

   g) I have the electron configuration $1s^2 2s^2 2p^3$.

   h) I have 18 neutrons and an atomic mass of 33.

   i) I have 4 electrons.

   j) I am in period 3 and form 2- charges when in an ion state.

   k) I am in period 3 and form 2+ charges when in an ion state.

l) I am in period 3 and combine with chlorine to form XCl_3. What is X?

m) I am in the same family as S, but have a smaller radius.

n) I am in period 3 and form a maximum charge of +4 when in ionic form.

o) I am in the same period as Oxygen, but am more reactive.

7. Explain the trends across a period when discussing

   a) Atomic radius

   b) Ionic radius

   c) Electronegativity

   d) First ionization energy

8. Explain the trends for a family when discussing

   a) Atomic radius

   b) Ionic radius

   c) Electronegativity

   d) First ionization energy

9. Explain why the third ionization energy of calcium is much more than that of the first or second ionization energy of calcium.

Kinetics

10. For the reaction

$$NO + H_2 \rightarrow HNO_2$$

The following kinetic data were collected at 800°C

Experiment #	[NO] (moles/L)	[H_2] (moles/L)	Initial Rate (moles/L sec)
1	0.001	0.004	0.002
2	0.002	0.004	0.008
3	0.003	0.004	0.018
4	0.004	0.001	0.008
5	0.004	0.002	0.016
6	0.004	0.003	0.024

a) What is the rate law expression for this reaction?

b) Calculate the rate constant, *k*.

11. When solid sodium is placed in water at room temperature, a violent reaction occurs:

$$Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g) + \text{energy}$$

a) Desctibe two methods that could be used to experimentally determine the rate of reaction.

b) State two reasons why some collisions may not result in a chemical reaction.

c) Describe the relationship between activation energy and the rate of a chemical reaction.

12. The isomerization of methyl isonitrile, CH_3NC, to acetonitrile, CH_3CN, was studied in the gas phase at 215°C, and the following data were obtained:

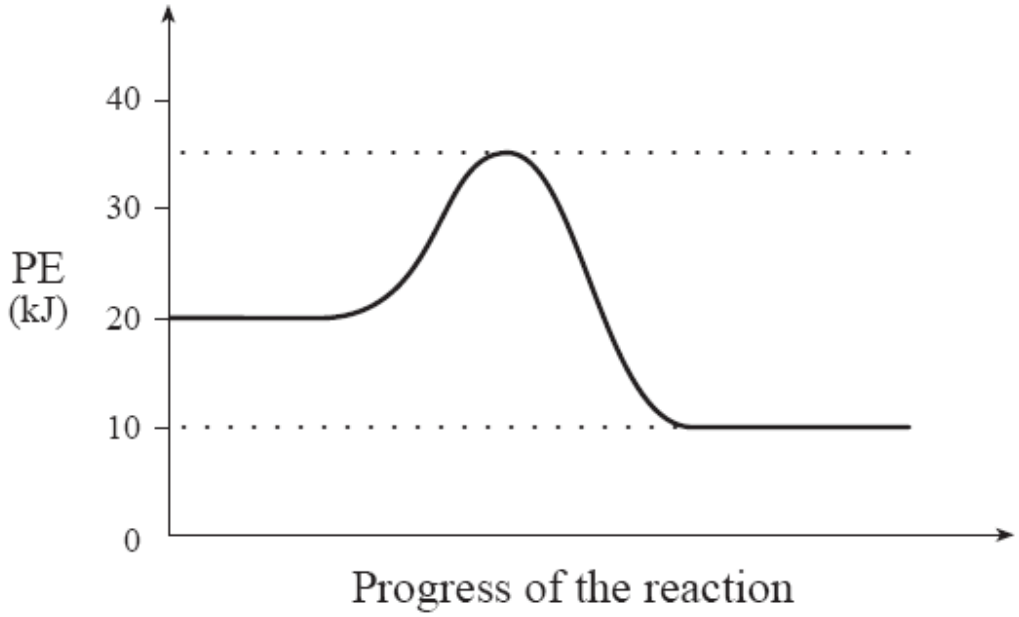
Time (s)	$[CH_3NC]$ (mol/L)
0	0.0165
2000	0.0110
5000	0.00591
8000	0.00314
12000	0.00137
15000	0.00074

a) Calculate the average rate of the reaction, in mol/L/s, for the 5000s to 12000s time interval.

b) Calculate the average rate for the 8000s to 15000s time interval.

c) Account for the difference in these two rates.

13. Consider the following potential energy diagram for a reversible reaction:



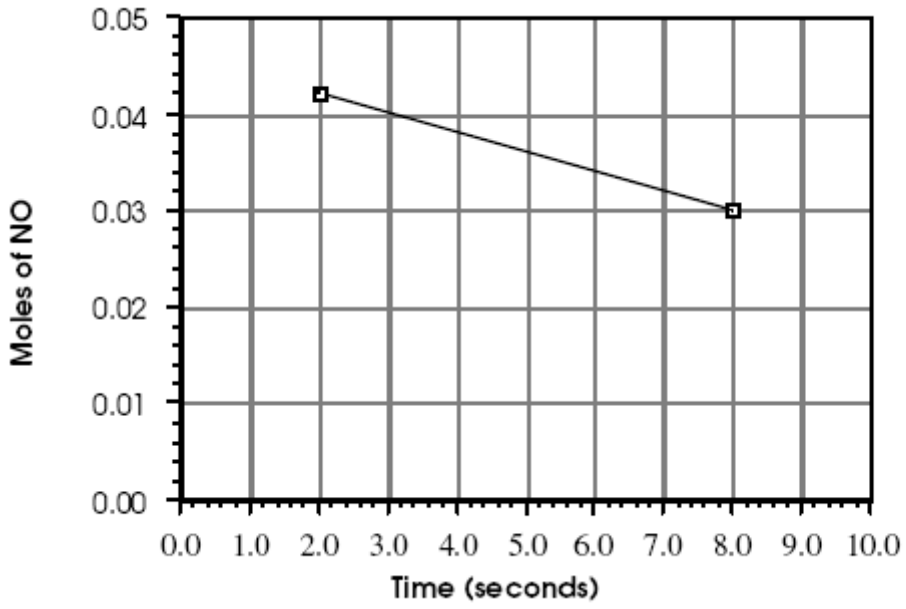
a) Calculate ΔH for the forward reaction.

b) Calculate the activation energy for the reverse reaction.

14. Consider the following reaction:

$$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

Data collected for the above reaction was used to construct the following graph:



a) From this graph, determine the **rate of reaction** in moles of NO consumed per second.

b) Using your answer in (a), calculate the average rate of production of N_2 gas.

Chemical Equilibrium

15. Consider the following equilibrium and the equilibrium constant values given for two temperatures:

$$CH_4(g) + H_2O\,(g) \leftrightarrow CO(g) + 3H_2(g)$$

K_c	Temperature
1.78×10^{-3}	800°C
4.68×10^{-2}.	1000°C

a) Is the forward reaction in this equilibrium exothermic or endothermic?

b) Explain your answer.

c) Are products or reactants favoured at a low temperature? Explain your answer.

16. A mixture of 0.75 mol of N_2 and 1.20 mol of H_2 are placed in a 3.0 liter container. When the reaction reaches equilibrium, $H_2 = 0.1$ mol. What is the value of $[N_2]$ and $[NH_3]$ at equilibrium

$$N_2\,(g) + 3H_2\,(g) \leftrightarrow 2NH_3\,(g)$$

17. Given the following equilibrium system, state which way the equilibrium will shift when the changes below are made:

$$2C_2H_{6(g)} + 7O_{2(g)} \leftrightarrow 4CO_{2(g)} + 6H_2O_{(g)} + \text{heat}$$

a) The *volume* of the container is halved.

b) The *temperature* is decreased.

c) CO_2 is added to the container.

d) O_2 gas is removed from the system.

e) A *catalyst* is added.

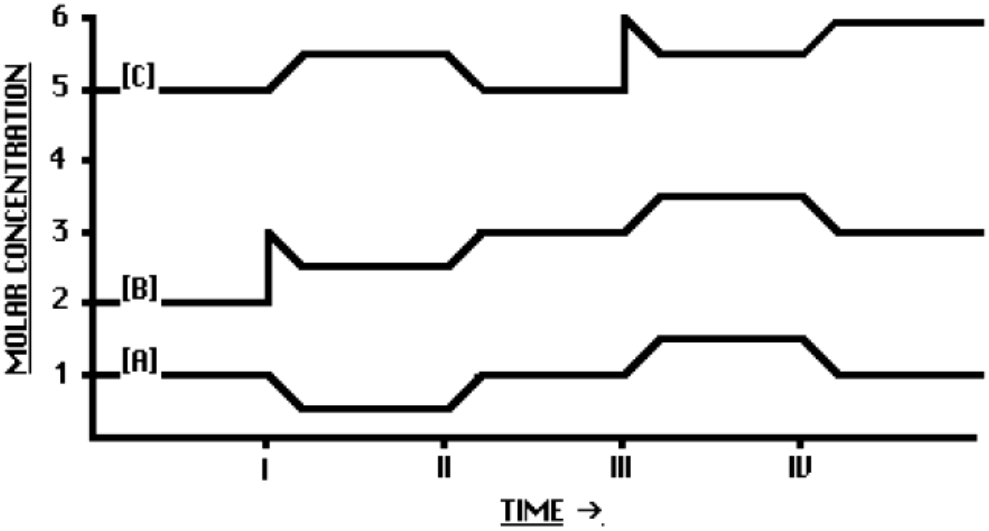
18. Consider the following equilibrium system:

$$PCl_3(g) + Cl_2(g) \leftrightarrow PCl_5(g)$$

At 250°C, 0.40 mol of PCl_3 and 0.60 mol of Cl_2 are placed into a 1.0 litre container. At equilibrium, the $[\ PCl_5\ ] = 0.11$ mol/L. Calculate the value of K_c.

19. Given the following graph showing the concentrations of species A, B and C, state what changes in **temperature** or **concentration** are responsible for each of the shifts shown on the graph. The equilibrium equation is:

$$A(g) + B(g) \leftrightarrow C(g) \qquad \Delta H = -65 \text{ kJ}$$



a) At time I, the _____

b) At time II, the _____

c) At time III, the _____

d) At time IV, the _____

20. What is the molar solubility of magnesium carbonate, $MgCO_3$ ($K_{sp} = 8.5 \times 10^{-8}$), in 1.0 L of a 0.020 mol/L solution of $CaCO_3$ solution?

21. Calculate the number of grams of CaC_2O_4 ($K_{sp} = 2.3 \times 10^{-9}$) which will dissolve in 1.5 L of water at 25°C.

22. Calculate the solubility in g/L of Silver Chloride in pure water (K_{sp} of AgCl = 1.6×10^{-10}):

Acid Base Equilibria

23. Define each of the following:

    a) Arrhenius acid.

    b) Arrhenius base.

    c) Brønsted-Lowry acid.

    d) Brønsted-Lowry base.

    e) Lewis acid.

    f) Lewis base.

24. Using water, demonstrate how HCO_3^- can behave as an acid or a base in a chemical reaction and define the term used to describe such a species.

25. Identify all acids/bases and their conjugates in the reactions in question 24..

26. When bromothymol blue indicator [HBb] is added to water, the following equilibrium exists:

$$H_2O_{(l)} + \underset{\text{YELLOW}}{HBb_{(aq)}} \leftrightarrow H_3O^+_{(aq)} + \underset{\text{BLUE}}{Bb^-_{(aq)}}$$

    Use Le Chatelier's Principle to explain what color you will see when:

    a) NaOH is added to the solution.

    b) HCl is added to the solution.

27. Calculate the pH of a 0.50 mol/l solution of H_2S.

28. A 0.75 mol/L solution of an unknown weak acid, H_2X, has a pH of 3.50. Determine the K_a.

29. Given that a 0.048 M acetic acid solution is 5.2% ionized, determine the pH at equilibrium.

Electrochemistry

30. Sketch a zinc/magnesium electrochemical cell, showing all ion movement. Label the anode and the cathode. Give the net cell reaction and voltage.

31. Draw a diagram and write the anode and cathode reactions for the electrolysis for molten barium chloride. Clearly indicate on your diagram the direction of electron flow.

32. Consider the following experimental results:

$$Ce^{4+} + Pd \rightarrow Pd^{2+} + Ce^{3+}$$
$$In^{3+} + Cd \rightarrow \text{no reaction}$$
$$Pd^{2+} + In^{2+} \rightarrow In^{3+} + Pd$$
$$Cd^{2+} + Pd \rightarrow \text{no reaction}$$

Use this data to create a reactivity series and list the species on the left side of the table (oxidizing agents) in order of increasing Reducing Strength.