NE 121 Fall 2005 Midterm
Multiple Choice Solutions

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§ Dr. Gilbert has posted solutions for the last two parts of the midterm (multiple choice with work + long answer) and is available from UW-ACE. What you're seeing is solutions to Part One – conceptual multiple choice.

The way I attack multiple choice problems is by giving each choice a rank. The ranks are: '×' (not an answer), '∼' (could be an answer), and '*' (definitely an answer). In doing so, the process of trial and error is crucial. If you were expecting elegant, straightforward answers you'll have to look elsewhere. We can hope to make progress only in fits and starts. Although this process can be cumbersome and frustrating at times, it is definitely worth the struggle.

The key to solving any problem in chemistry is the *analysis* we do at the beginning. I find this point isn't stressed quite enough. If the analysis is right, that's half the battle won and 75% of the problem solved. In the forthcoming solutions, I will try to guide you through the analysis I may have gone through before picking a specific answer.

> "If your understanding of chemical concepts is not sufficient to allow you to solve problems involving 'twists' that you have never encountered before, your knowledge is not very useful to you." – Zumdahl

1. Which of the following is not a state function?

   A. q_v is q at constant volume. Path is defined. ×

   B. q_p is q at constant pressure. Path is defined. ×

   C. q_{rev} is q for a reversible process. Path is defined. ×

   D. q is the odd one out. ∼

   E. $q + w$ is ΔE by the formula $\Delta E = q + w$, and ΔE is a state function. ×

2. Why does frozen meat thaw faster on a piece of aluminum than on the counter?

   We begin with the formula $Q = nC_p\Delta T = mc\Delta T$. If frozen meat thaws faster when in contact with aluminum, the equilibrium temperature must be farther away from its current temperature than when on the counter. The only plausible reason this could be true is that aluminum absorbs more heat from the meat than the counter does. Therefore, its heat capacity C_p must be higher. Answer is A.

3. For which type of expansion of an ideal gas is $q = \Delta E$

   We already know the formula $\Delta E = q + w$. Now, if q is to equal ΔE, w has got to be 0. This w is the physical (not nRT) work that the system might do. The only case when this is true is in the case of constant volume since the container does not permit the gas to expand. Analogous to the work formula for a constant force $W = Fd$, we can think $W = F\Delta V$. Since $\Delta V = 0$, $W = 0$ and the system cannot do any work. Answer is B.

4. Which of the following statements regarding a system at equilibrium is false?

   We use (Gaussian) elimination to solve this one.

   A. The rate of the forward reaction equals the rate of the reverse reaction. At equilibrium, the forward and backward rates are certainly equal. This is one of the definitions of macroscopic equilibrium. $\times$

   B. The concentrations of the products and the reactants do not change. As consequence of A., this one has to be true too. But keep in mind that all equilibria except redox are dynamic equilibria, ie. the reaction occurs both ways, but the rates are the same. To the naked eye, it seems nothing is happening and concentrations remain the same. $\times$

   C. The change in enthalpy is equal to zero. Hmm, this might be true. I don't know. $\sim$

   D. A system that is disturbed will react to restore equilibrium. Oh wait. I know this is true for sure. Isn't this what Le Châtelier's principle predicts? $\times$

   Ok, let's try to reason why C might be true. I like thermodynamics, so let's use it. I know for one that ΔG for a system at equilibrium is 0. But I also know that ΔS for a system at equilibrium need not be 0 as illustrated during the fusion or vaporization of water. If $\Delta G = 0$ and $\Delta S \neq 0$, then $\Delta H \neq 0$ for a given system at equilibrium by the equation $\Delta G = \Delta H - T\Delta S$. C therefore seems a wise choice.

5. Which of the following pairs of compounds will form a pH buffer solution?

   There was actually an error in this question. It should have read "not form a buffer solution." Nonetheless, there's no reason why we shouldn't be able to get the right answer(s). First off, there's nothing that says that there can't be more than one answer for a said multiple choice question (hint: the name gives it away). If you know your stuff, you should be able to point out the mistake. Let's assume there's no error in the question and solve it anyway.

   First, ask yourself: What chemical concept is question testing me on? If we look at the choices, we have a range of weak/strong acids and their salts, or a salt of a weak base and the base itself. Clearly, the question is attempting to find out if you know that **strong acids and bases do not form buffers**. This is because their conjugates are so weak that they don't make effective acid or base absorbers. Strong acids and bases therefore work one way only.

   The only strong acid in question is B, HNO_3. All of the others are weak acids and their salts. Well, you may ask, how do we know this. Part of it is just experience. I know HNO_3 is a strong acid because I did an entire lab on it. I even spilled some onto my hands and I had some eat into my jeans. I know the rest are weak acids because I've been doing acid-base for more than two years now. You may know it because you saw it in the textbook or in one of the assignment problems.

   Another cool trick is to find the answer in some other part of the exam. If you were unsure (like me) if HF was a weak acid or not, you simply had to surf to page 4 of the exam where the pKa for hydrofluoric acid HF is given to be pKa = 3.18, so Ka = $10^{-3.18} = 6.6 \times 10^{-4}$. Clearly HF is a weak acid.

   Thus the answer is: "All but B".

6. Which of the following does not increase the entropy of the system?

   Melting, sublimation, evaporation and warming are all changes from a state of lower energy to one of higher energy. This increases the kinetic energy of the molecules and therefore their entropy. The odd one out is E, condensing a liquid. This is the answer.

7. Which of the following statements is false?

As the options aren't really correlated, we'd have to look at each one on a case-by-case basis.

A. Most ionic compounds are strong electrolytes. Well this has to be true. I remember Prof. Gilbert saying this in class. Moreover, I did an experiment with NaCl and sugar ($C_{12}H_{22}O_{11}$) in different beakers. The former conducted electricity because it lit my light bulb and the latter didn't. The reason is that ionic compounds produce lots of ions in solution while molecular compounds stay intact for the most part. $\times$

B. Most molecular compounds are non- or weak electrolytes. Well, the sugar in option A was molecular/covalent. It doesn't break into ions when dissolved. Note: just because sugar dissolves in water, doesn't mean it's an electrolyte. $\times$

C. Insoluble salts can form from soluble ions. Well, this one's got to be true. For instance, I know sodium chloride AgCl is insoluble in water. But it can form via precipitation reactions from Ag^+ and Cl^- ions both of which can exist as ions in solution. $\times$

D. Dissociation of acids produce hydride ions. If you see Table 2.3 on p.35 of Zumdahl, the hydride ion is the H^- ion. But we all know that acids which dissociate by reacting with water as a base form hydronium (H_3O^+), not hydride ions. This one's false for sure. *

E. The net ionic reaction includes only the ions that participate in the solution. This follows from the definition of a net ionic equation. Must be true. $\times$

Answer is D.

8. If the equilibrium constant for the reaction A + B → C is K, what is the equilibrium constant for the reaction 2C → 2A + 2B?

The trick is in identifying that the arrow points in the same direction. If you reverse a reaction, $K' = \frac{1}{K}$, and if you multiply a reaction by a constant n, $K' = K^n$. Order doesn't matter here so flipping a reaction and multiplying throughout by 2 gives a new equilibrium constant $K' = \frac{1}{K^2}$.

Answer is E.

9. The Ksp for $Ca(OH)_2$ = _______, where S is the molar solubility of $Ca(OH)_2$.

It is always a good idea to write out the solubility reaction first, no matter how simple or easy the problem may seem.

$$Ca(OH)_{2\ (aq)} \rightleftharpoons Ca^{2+}{}_{(aq)} + 2OH^-{}_{(aq)}$$

and since $2 \times [Ca^{2+}]$ must equal $[OH^-]$ because of the reaction's stoichiometry, we can denote the concentrations of Ca^{2+} and OH^- in terms of the solubility S of $Ca(OH)_2$ like so:

$$\begin{aligned} Ksp &= [Ca^{2+}] \times [OH^-]^2 \\ &= (S) \times (2S)^2 \\ &= 4S^3 \end{aligned}$$

Answer is B.

10. The pH of a NaCl solution is:

When NaCl dissolves in water, it readily dissociates into it's constituent ions Na^+ and Cl^-. Na^+ is a Group 1 alkali metal that acts as neither an acid or a base. (Most Group 1 and Group 2 metals share this property). Cl^- on the other hand is the conjugate base of a very strong acid HCl. It is therefore such a weak base that we don't even consider it a base anymore. So since both ions in solution are not acid-base active, the solution remains neutral and the pH is $-log(\sqrt{K_w}) = 7.00$ at 25 °C.

Answer is A. §