

2022 Spring Semester Final Examination For General Chemistry I

Date: June 15 (Wed), Time Limit: 19:00 ~ 21:00

Write down your information neatly in the space provided below; print your Student ID in the upper right corner of every page.

Professor Name	Class	Student I.D. Number	Name

Problem	points	Problem	points	TOTAL pts
1	/7	7	/12	/100
2	/8	8	/6	
3	/10	9	/10	
4	/12	10	/14	
5	/8	11	/6	
6	/7			

** This paper consists of 16 sheets with 11 problems (*page 14 - 15*: Equation, constants & periodic table, *page 16*: claim form). Please check all page numbers before taking the exam. Write down your work and answers in the Answer sheet. Please write down the unit of your answer when applicable. You will get 30% deduction for a missing unit.

NOTICE: SCHEDULES on RETURN and CLAIM of the MARKED EXAM PAPER.

(채점 답안지 분배 및 이의신청 일정)

1. Period, Location and Procedure

1-1) For students who took the off-line Examination

0 Return and Claim Period: **June 17** (Fri, 12:00 ~ 14:00, 2 hrs)

The claim is permitted only on this period. Keep that in mind!

0 Location: Each designated room of Creative Learning Bldg. (E11)

Class	Room(E11)	Class	Room(E11)
A	101	D	301
B	102	E	302
C	103	F	303

0 Procedure

Rule 1: Students cannot bring their writing tools into the rooms (Use a pen only provided by TA)

Rule 2: With or without claim, you must submit the paper back to TA. (Do not go out of the room with it)

If you have any claims on it, write them on the claim form and attach it to the top of the exam paper with a stapler.
Give them to your TA.

WARNING!!

If you deliberately alter any original answers or insert something on your marked paper to achieve a better grade, you will get a F grade for this course. Or if you don't keep the rules above, we will regard it as a kind of cheating and give you 0 point. So please don't cheat.

1-2) For Students who took the online examination

0 Claim Period: *June 17* (Fri, 12:00 ~ 14:00, 2 hrs)

The claim is permitted only on this period. Keep that in mind!

0 Location: Each class of Turnitin site

0 Procedure

If you have any claims on it, email them (Question# and reasons) to *each TA in charge of the # of each question*.
The TA name and email addresses will be announced on the General Chemistry Website.

2. Final Confirmation

1) Period: *June 18(Sat) ~ 19(Sun)*

2) Procedure: During this period, you can check final score of the examination *on the website* again.

(No additional corrections. If no change in your score after reasoning, the claims were not accepted.)

**** For further information, please visit General Chemistry website at www.gencheminkaist.pe.kr**

1. (total 7 pts)

(a) At 90 °C, the vapor pressure of toluene is 0.534 atm and the vapor pressure of benzene is 1.34 atm. Benzene (0.400 mol) is mixed with toluene (0.900 mol) to form an ideal solution. Compute the mole fraction of benzene in the vapor in equilibrium with this solution.

(b) Calculate the mole fraction of toluene in a mixture of benzene and toluene that boils at 90 °C under atmospheric pressure.

(c) Which liquid can be extracted by vapor from the original solution by conducting fractional distillation multiple times? Explain.

(answer)

(a) **3 pts**

$$P_{\text{toluene}} = X_{\text{toluene}} P^{\circ}_{\text{toluene}} = \left(\frac{0.900}{0.400 + 0.900} \right) (0.534 \text{ atm}) = 0.370 \text{ atm}$$

$$P_{\text{benzene}} = X_{\text{benzene}} P^{\circ}_{\text{benzene}} = \left(\frac{0.400}{0.400 + 0.900} \right) (1.34 \text{ atm}) = 0.412 \text{ atm}$$

$$\therefore X_{\text{benzene}} = \frac{0.412}{0.370 + 0.412} = 0.527$$

(b) **2 pts**

$$(0.534 \text{ atm})X_{\text{toluene}} + (1.34 \text{ atm})(1 - X_{\text{toluene}}) = 1.00 \text{ atm}$$
$$X_{\text{toluene}} = 0.42$$

(c) Benzene will be isolated, since it has higher vapor pressure and lower boiling point. Each time fractional distillation is conducted, benzene will have a higher mole fraction in the vapor phase and will be obtained in a greater amount. **2 pts**

2. (total 8 pts)

Calculate ΔS_{sys} , ΔS_{surr} , and ΔS_{tot} for the irreversible isothermal expansion at 398 K of 1.00 mol of an ideal gas (system) from a pressure of 10.0 atm to constantly held external pressure of 1.00 atm.

(Answer) ΔS_{sys} 3 pts, ΔS_{surr} 4 pts, ΔS_{tot} 1 pt

Since S is a function of state, ΔS_{sys} for the irreversible process is equal to ΔS_{sys} for the reversible process with the same initial and final states.

$$\begin{aligned}\text{Thus, } \Delta S_{\text{sys}} &= q_{\text{rev}}/T = -w/T = -[-nRT \ln (V_2/V_1)]/T = -[-nRT \ln (P_1/P_2)]/T = nR \ln (P_1/P_2) \\ &= (1.00 \text{ mol})(8.315 \text{ J K}^{-1} \text{ mol}^{-1}) \ln (10.0 \text{ atm}/1.00 \text{ atm}) \\ &= 19.14 \text{ J K}^{-1}\end{aligned}$$

$$\begin{aligned}\Delta S_{\text{surr}} &= (\text{heat given up by the surrounding})/T = -(\text{heat absorbed by the system})/T \\ &= -q_{\text{irrev}}/T = -(-w_{\text{irrev}})/T = (w_{\text{irrev}})/T = -P_{\text{ext}}\Delta V/T = -(1 \text{ atm})(V_f - V_i)/T\end{aligned}$$

$$V_i = nRT/P_i = (1.00 \text{ mol})(0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1})(398 \text{ K})/10.0 \text{ atm} = 3.24 \text{ L}$$

$$V_f = nRT/P_f = (1.00 \text{ mol})(0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1})(398 \text{ K})/1.00 \text{ atm} = 32.4 \text{ L}$$

Thus,

$$\begin{aligned}\Delta S_{\text{surr}} &= -(1 \text{ atm})(V_f - V_i)/T = - (1 \text{ atm})(32.4 \text{ L} - 3.24 \text{ L})/398 \text{ K} = - (29.16 \text{ L atm})/398 \text{ K} \\ &= - (29.16 \text{ L atm})(101.3 \text{ J}/1 \text{ L atm}) /398 \text{ K} = - 7.42 \text{ J K}^{-1}\end{aligned}$$

$$\text{Hence, } \Delta S_{\text{tot}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} = 19.14 \text{ J K}^{-1} + (- 7.42 \text{ J K}^{-1}) = 11.72 \text{ J K}^{-1}$$

3. (total 10 pts)

Select the alphabet of the correct answer.

a) In a spontaneous process, which of the following always increases?

- A) the entropy of the system
- B) the entropy of the surroundings
- C) the entropy of the universe
- D) the entropy of the system and the universe
- E) the entropy of the system, surroundings and the universes

b) A process is always spontaneous, regardless of temperature, when _____ (H and S refer to the system) .

- A) $\Delta H > 0$ and $\Delta S < 0$
- B) $\Delta H < 0$ and $\Delta S < 0$
- C) $\Delta H > 0$ and $\Delta S > 0$
- D) $\Delta H < 0$ and $\Delta S > 0$
- E) None of these is true, as temperature must always be taken into account.

c) the dissolution of ammonium nitrate in water is a spontaneous endothermic process. It is spontaneous because the system undergoes _____.

- A) a decrease in enthalpy.
- B) an increase in entropy
- C) an increase in enthalpy.
- D) a decrease in entropy.
- E) an increase in free energy.

d) Any reaction will be spontaneous if _____

- A) $\Delta G_{\text{sys}} > 0$
- B) $\Delta G_{\text{sys}} < 0$
- C) $\Delta H_{\text{sys}} > 0$
- D) $\Delta S_{\text{sys}} < 0$
- E) $\Delta H_{\text{sys}} < 0$

e) The entropy of vaporization of water is 109.0 J/molK. What is the enthalpy of vaporization of water at its normal boiling point of 100°C?

- A) +10.90 kJ/mol
- B) -40.66 kJ/mol
- C) +3.42 kJ/mol
- D) +40.66 kJ/mol
- E) -10.90 kJ/mol

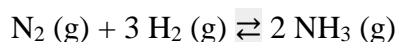
Answer

- a) C
- b) D
- c) B
- d) B
- e) D

4. (total 12 pts)

Substance	ΔH_f° (KJ/mol)	S° (J/mol·K)
N_2 (g)	0	191.5
H_2 (g)	0	130.6
NH_3 (g)	-46.1	192.6

a) Is the reaction spontaneous in the forward direction at 25°C? Explain it.



b) Estimate the highest temperature at which spontaneity is preserved, assuming that ΔH° and ΔS° remain roughly constant throughout.

c) Compute the equilibrium constant at 25°C.

d) Suppose that hydrogen, nitrogen, and ammonia gas are mixed together in a closed vessel, each component having a partial pressure of 4.0 atm. Is the mixture in equilibrium at 25°C? If not, predict in which direction a reaction will proceed.

(Sol)

a) 4 pts (H, S, G, answer each 1 pt)

$$\begin{aligned} \Delta H^\circ &= 2 \Delta H_f^\circ[NH_3(g)] - \Delta H_f^\circ[N_2(g)] - 3 \Delta H_f^\circ[H_2(g)] \\ &= (2 \text{ mol})(-46.1 \text{ KJ/K}) - 0 - 3 \times (0) = -92.2 \text{ KJ} \\ \Delta S^\circ &= 2 S^\circ[NH_3(g)] - S^\circ[N_2(g)] - 3 S^\circ[H_2(g)] \\ &= 2 \text{ mol} \times \frac{192.3 \text{ J}}{\text{mol} \cdot \text{K}} - 1 \text{ mol} \times \frac{191.5 \text{ J}}{\text{mol} \cdot \text{K}} - 3 \text{ mol} \times \frac{130.6 \text{ J}}{\text{mol} \cdot \text{K}} \\ &= -198.7 \text{ J/K} = -0.1987 \text{ KJ/K} \\ \Delta G^\circ &= \Delta H^\circ - T \Delta S^\circ = -92.2 \text{ KJ} - (298.15 \text{ K})(-0.1987 \text{ KJ/K}) \\ &= -92.2 \text{ KJ} + 59.24 \text{ KJ} = -33.0 \text{ KJ} \end{aligned}$$

The negative sign shows that the reaction is spontaneous.

b) 2 pts

The crossover ($\Delta G^\circ=0$) is reached when $\Delta H^\circ=T\Delta S^\circ$.

$$T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{-92.2 \text{ KJ}}{-0.1987 \text{ KJ/K}} = 464 \text{ K}$$

The highest possible temperature for a spontaneous reaction.

c) 2 pts

$$K = \exp\left(-\frac{\Delta G^\circ}{RT}\right) = \exp\left[-\left(\frac{-33.0 \text{ kJ}}{(8.3145 \text{ J/K})(298 \text{ K})}\right) \times \frac{1000 \text{ J}}{\text{kJ}}\right] = 6.1 \times 10^5$$

d) 4 pts

$$Q = \frac{P_{NH_3}^2}{P_{N_2}P_{H_2}^3} = \frac{(4.0)^2}{(4.0)(4.0)^3} = 0.062$$

This differs substantially from the equilibrium constant at 25°C ($K=6.1 \times 10^5$). The mixture is not yet at equilibrium.

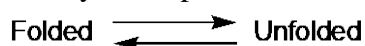
2 pts

There are still too many reactants and too few products (forward).

2 pts

5. (total 8 pts)

The single step unfolding reaction for many small proteins can be represented by the equilibrium.



The position of this equilibrium changes with temperature; the melting temperature T_m is defined as the temperature at which half of the molecules are unfolded and half are folded. The intensity of the fluorescence signal at a wavelength of 356 nm of a 1.0 μM sample of the protein was measured as a function of temperature over the range 58 to 66 $^{\circ}\text{C}$:

Temperature ($^{\circ}\text{C}$)	58	60	62	64	66
Fluorescence intensity (arbitrary units)	27	30	34	37	40

A 1.0 μM sample in which all of the protein molecules are folded gives a fluorescence signal of 21 units at 356 nm. A 1.0 μM sample in which all of the protein molecules are unfolded gives a fluorescence signal of 43 units. Assuming that the fluorescence intensity from each species is directly proportional to its concentration.

- Calculate the fraction, X_{unfold} , of unfolded molecules present at 64 $^{\circ}\text{C}$.
- Calculate the equilibrium constant at 64 $^{\circ}\text{C}$.
- Estimate the value of T_m for this protein (to the nearest 1 $^{\circ}\text{C}$)

(Answer)

(a)

Because concentration is proportional to the fluorescence intensity (I),

$$\begin{aligned} I_{\text{tot at } 64^{\circ}\text{C}} &= 37 = I_{\text{fold}} + I_{\text{unfold}} = 21X_{\text{fold}} + 43 X_{\text{unfold}} \\ &= 21(1-X_{\text{unfold}}) + 43 X_{\text{unfold}} \end{aligned}$$

$$X_{\text{unfold}} = 0.73 \quad (2 \text{ pts})$$

(b)

$$K = \frac{[\text{unfolded}]}{[\text{folded}]} = \frac{X_{\text{unfolded}}}{X_{\text{folded}}} = 0.73/(1-0.73) = 2.7 \quad (2 \text{ pts})$$

(c)

Calculations of K depending on the given temperatures afford:

Temperature (°C)	58	60	62	64	66
K	0.38	0.69	1.4	2.7	6.3

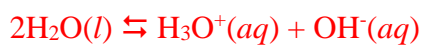
At T_m , $K = 1$. Thus, the best estimation of T_m is 61 °C.

(4 pts)

6. (total 7 pts)

Pure water has a pH of 7.00 at 25 °C and 7.27 at 10 °C. Calculate the enthalpy change (ΔH^0) in kJ/mol for the autoionization of water, and predict the pH of pure water at 50 °C.

Answer:



$$K_{w,25C} = [\text{H}_3\text{O}^+][\text{OH}^-] = (10^{-\text{pH}})^2 = 1.00 \times 10^{-14}$$

$$K_{w,10C} = [\text{H}_3\text{O}^+][\text{OH}^-] = (10^{-\text{pH}})^2 = 2.88 \times 10^{-15}$$

$$\ln\left(\frac{K_{w,25C}}{K_{w,10C}}\right) = -\frac{\Delta H^0}{R}\left(\frac{1}{273+25} - \frac{1}{273+10}\right)$$

$$\Delta H^0 = 58.2 \text{ kJ/mol}$$

4 pts

$$\ln\left(\frac{K_{w,50C}}{K_{w,25C}}\right) = -\frac{\Delta H^0}{R}\left(\frac{1}{273+50} - \frac{1}{273+25}\right)$$

or

$$\ln\left(\frac{K_{w,50C}}{K_{w,10C}}\right) = -\frac{\Delta H^0}{R}\left(\frac{1}{273+50} - \frac{1}{273+10}\right)$$

$$K_{w,50C} = ([\text{H}_3\text{O}^+])^2 = 6.16 \times 10^{-14}$$

$$\therefore \text{pH at } 50^\circ\text{C} = 6.61$$

3 pts

7. (total 12 pts)

Calculate pH of given solutions below. (pK_a of HCOOH in water: 3.7, pK_a of HClO in water: 7.5) Both HCOOH and HClO are monoprotic. Assume there is only acid-base reaction and no reaction between two acids.

(a) 0.1 M HCOOH(aq)

(b) 0.1 M HClO(aq)

(c) 0.1 M HCOOH(aq) 100mL + 0.1 M NaOH(aq) 50 mL

(d) 0.1 mM HCOOH(aq) 100mL + 0.1 mM NaOH(aq) 50 mL

(e) 0.3 M HCOOH(aq) 50mL + 0.3 M HClO(aq) 50 mL + 0.3 M NaOH(aq) 50 mL

Answer:

(a) (2 pts) For a weak acid, $pH = -\frac{1}{2}\log(CK_a) = -\frac{1}{2}\log(0.1) + \frac{3.7}{2} = 2.35$

(b) (2 pts) For a weak acid, $pH = -\frac{1}{2}\log(CK_a) = -\frac{1}{2}\log(0.1) + \frac{7.5}{2} = 4.25$

(c) (2 pts) By NaOH, half of HCOOH became $HCOO^-$. As the amount of HCOOH and its conjugate base are the same, Henderson-Hasselbalch equation gives $pH = pK_a + \log\left(\frac{[HCOO^-]}{[HCOOH]}\right) = 3.7$.

(d) (3 pts) By NaOH, half of HCOOH became $HCOO^-$ and their concentration are 1/30 mM each. After then, HCOOH additionally dissociate to H^+ and $HCOO^-$ to satisfy its K_a . Let $[H^+] = x$ and we obtain the equation,

$$\frac{\left(\frac{1}{30000} + x\right)x}{\frac{1}{30000} - x} = 10^{-3.7}, x = 2.57 \times 10^{-5}$$

Thus, $pH = 4.59$.

(e) (3 pts) The initial concentration of HCOOH, HClO in a mixed solution is 0.1 M each. Let (final concentration of $HCOO^-$) = x , (that of ClO^-) = y , and (that of H^+) = z . Then, we get a simultaneous equation,

$$\frac{xz}{\frac{1}{10} - x} = 10^{-3.7}, \quad \frac{yz}{\frac{1}{10} - y} = 10^{-7.5}, \quad x + y = \frac{1}{10}$$

$$\text{Since } \frac{1}{10} - x = y \text{ and } \frac{1}{10} - y = x,$$

$$\frac{xz}{y} = 10^{-3.7}, \quad \frac{yz}{x} = 10^{-7.5}$$

$$\therefore \frac{xz}{y} \times \frac{yz}{x} = z^2 = 10^{-3.7} \times 10^{-7.5} = 10^{-11.2}$$

By solving this, we can obtain $[H^+] = 2.51 \times 10^{-6}$, thus $pH = 5.6$.

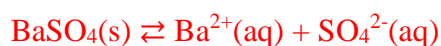
(Any other solution which yields $pH=5.6$ will be accepted)

8. (total 6 pts)

Barium sulfate (BaSO_4) is used in medical imaging of the gastrointestinal tract. Its solubility product is 1.08×10^{-10} at 25°C , so it is ideally suited for this purpose because of its low solubility when a “barium milkshake” is consumed by a patient. The pathway of the sparingly soluble salt can be easily monitored by x-rays. Will barium sulfate precipitate if 10.0 mL of 0.0020 M Na_2SO_4 is added to 100 mL of 3.2×10^{-4} M BaCl_2 ? Explain why and recall that NaCl is highly soluble in water.

(Answer)

The only slightly soluble salt that can be formed when these two solutions are mixed is BaSO_4 because NaCl is highly soluble.



The solubility product expression is as follows:

$$K_{\text{sp}} = [\text{Ba}^{2+}][\text{SO}_4^{2-}] = 1.08 \times 10^{-10}$$

The concentrations of Ba^{2+} and SO_4^{2-} are obtained when the number of moles of Ba^{2+} and that of SO_4^{2-} are divided by the final volume (100 mL + 10.0 mL = 110 mL = 0.11 L):

$$[\text{Ba}^{2+}] = \frac{(0.100 \text{ L})(3.2 \times 10^{-4} \text{ mol L}^{-1})}{0.11 \text{ L}} = 2.9 \times 10^{-4} \text{ M}$$

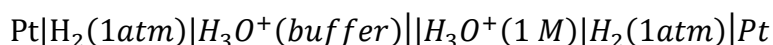
$$[\text{SO}_4^{2-}] = \frac{(0.010 \text{ L})(2.0 \times 10^{-3} \text{ mol L}^{-1})}{0.11 \text{ L}} = 1.8 \times 10^{-4} \text{ M}$$

$$Q = [\text{Ba}^{2+}][\text{SO}_4^{2-}] = (2.9 \times 10^{-4})(1.8 \times 10^{-4}) = 5.2 \times 10^{-8}$$

Because $Q > K_{\text{sp}}$, we predict that BaSO_4 will precipitate when the two solutions are mixed. In fact, BaSO_4 will continue to precipitate until the system reaches equilibrium, which occurs when $[\text{Ba}^{2+}][\text{SO}_4^{2-}] = K_{\text{sp}} = 1.08 \times 10^{-10}$.

9. (total 10 pts)

With 100 mL of 1 M HCl and a buffer solution (1 M CH_3COOH solution 55 mL and 1 M CH_3COONa solution 45 mL)



Na^+ , CH_3COO^- doesn't participate in cell reactions.

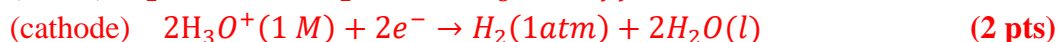
pK_a of CH_3COOH is 4.74, and molar mass of NaOH is 40 g/mol.

(a) Write anode and cathode half reactions. And calculate the E_{cell} of the cell.

(b) 0.2 g of NaOH was added to the buffer solution. Calculate the changed E_{cell} .

Solution

(a) 6 pts



By using Henderson-Hasselbalch Equation, $pH = pK_a - \log_{10} \frac{[CH_3COOH]_0}{[CH_3COO^-]_0} = 4.65$.

$$Q = \frac{[H_3O^+(buffer)]^2}{[H_3O^+(HCl)]^2}$$

$$E_{cell} = 0 - \frac{0.0592V}{2} (\log_{10}[H_3O^+(buffer)]^2 - \log_{10}[H_3O^+(HCl)]^2) = 0.0592V \times [pH(buffer)]$$

$$= 0.27528 V$$

(4 pts)

(b) 4 pts

First, NaOH 0.2g is 0.005 mol of NaOH.

By reaction $CH_3COOH(aq) + OH^-(aq) \rightarrow H_2O(l) + CH_3COO^-(aq)$, moles of $CH_3COOH = 0.055mol - 0.005mol = 0.050mol$,

moles of $CH_3COO^- = 0.045mol + 0.005mol = 0.050mol$. $pH = pK_a - \log \frac{[CH_3COOH]_0}{[CH_3COO^-]_0} =$

$pK_a = 4.74$ **(2 pts)**

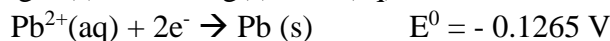
So, $E_{cell} = \frac{0.0592V}{2} (pH(buffer)) = 0.2806 V$ **(2 pts)**

10. (total 14 pts)

A student decided to measure the solubility of lead acetate (Pb(OAc)₂) in water and sets up the electrochemical cell.

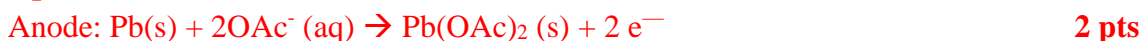


At 25°C, the student finds the cell potential to be 0.546V, and from the textbook he also finds,



(a) What are the electrochemical formula of anode, cathode and net reactions?

4 pts



(b) Calculate the E⁰ of anode, cathode and total cell.

4 pts

Using Nernst equation, $E_{\text{cell}} = E^0_{\text{cell}} - 0.0592/n \log Q$

where $n=2$, and $Q = [\text{Cl}^-]^2 / [\text{OAc}^-]^2 = (0.5)^2 / (0.05)^2 = 100$

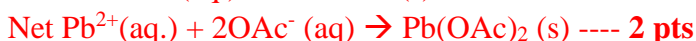
E_{cell} measured as 0.546V, $E_{\text{cell}}^0 = E_{\text{cell}} + 0.0592/n \log Q = 0.546 + 0.0592 = 0.6052\text{V}$

Since, $E_{\text{cell}}^0 = E^0_{\text{cathode}} - E^0_{\text{anode}}$

$E^0_{\text{cathode}} = 0.222\text{V}$, E^0_{anode} becomes -0.3832V

(c) What does the student find for the K_{sp} of Pb(OAc)₂? (Write the net reaction)

6 pts



$E^0_{\text{cell}} = -0.1265 - (-0.3832)$

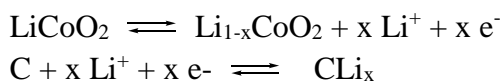
$= 0.2567\text{V}$ -----**1 pt**

$\Delta G^0_{\text{cell}} = -nFE^0_{\text{cell}} = -(2\text{mol})(96485 \text{ C mol}^{-1})(0.2567) = -49.535 \text{ kJ}$ -----**1 pt**

ΔG^0 of the dissolution reaction of Pb(OAc)₂(s) is 49.535 kJ, $K_{\text{sp}} = \exp(-\Delta G^0/RT) = \exp(-49535\text{J} / (8.314 * 298.15)) = 2.10 \times 10^{-9}$ -----**2 pts**

11. (total 6 pts)

Lithium cobalt oxide and specialty carbon are active ingredients for the positive and negative electrodes, respectively, of a rechargeable lithium battery. During the charge/recharge cycles, the following reversible half-reactions occur.



Graphite has lithium intercalation sites between its layers. Assuming a maximum 6:1 carbon-to-lithium intercalation stoichiometry, calculate the theoretical charge capacity of 1.00 gram of graphite to intercalate lithium. Answer in mAh/g. The total amount of energy a battery can store (charge capacity) is rated in mAh. For example, a battery rated at 1500 mAh can power a device drawing 100 milliamps for 15 hours.

(Answer)

1.00 g graphite (C) = 0.0833 mol carbon

6 mol carbon to 1 mol lithium; 1 g graphite can hold 0.0139 mol lithium

To insert 1 mol lithium, 96487 coulombs are needed.

Therefore, 1 g graphite can charge $96487 \times 0.0139 = 1340$ coulombs.

$1340 \text{ coulombs} / \text{g} = 1340 \text{ A sec} / \text{g}$

$= 1340 \times 1000 \text{ mA} \times (1 / 3600) \text{ h} = 372 \text{ mAh} / \text{g}$ (6 pts)

Physical Constants

Avogadro's number	$N_A = 6.02214179 \times 10^{23} \text{ mol}^{-1}$
Bohr radius	$a_0 = 0.52917720859 \text{ \AA} = 5.2917720859 \times 10^{-11} \text{ m}$
Boltzmann's constant	$K_B = 1.3806504 \times 10^{-23} \text{ J K}^{-1}$
Electronic charge	$e = 1.602176487 \times 10^{-19} \text{ C}$
Faraday constant	$F = 96485.3399 \text{ C mol}^{-1}$
Masses of fundamental particles:	
Electron	$m_e = 9.10938215 \times 10^{-31} \text{ kg}$
Proton	$m_P = 1.672621637 \times 10^{-27} \text{ kg}$
Neutron	$m_n = 1.674927211 \times 10^{-27} \text{ kg}$
Permittivity of vacuum	$\epsilon_0 = 8.854187817 \times 10^{-12} \text{ C}^{-2} \text{ J}^{-1} \text{ m}^{-1}$
Planck's constant	$h = 6.62606896 \times 10^{-34} \text{ J s}$
Ratio of proton mass to electron mass	$m_P / m_e = 1836.15267247$
Speed of light in a vacuum	$c = 2.99792458 \times 10^8 \text{ m s}^{-1}$ (exactly)
Standard acceleration of terrestrial gravity	$g = 9.80665 \text{ m s}^{-2}$ (exactly)
Universal gas constant	$R = 8.314472 \text{ J mol}^{-1} \text{ K}^{-1}$ $= 0.0820574 \text{ L atm mol}^{-1} \text{ K}^{-1}$

Values are taken from the 2006 CODATA recommended values, as listed by the National Institute of Standards and Technology.

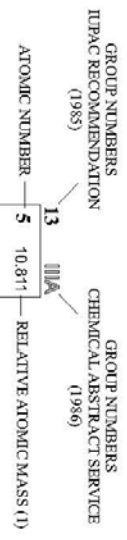
Conversion factors

Ångström	$1 \text{ \AA} = 10^{-10} \text{ m}$
Atomic mass unit	$1 \text{ u} = 1.660538782 \times 10^{-27} \text{ kg}$ $1 \text{ u} = 1.492417830 \times 10^{-10} \text{ J} = 931.494028 \text{ MeV}$ (energy equivalent form $E = mc^2$)
Calorie	$1 \text{ cal} = 4.184 \text{ J}$ (exactly)
Electron volt	$1 \text{ eV} = 1.602177 \times 10^{-19} \text{ J} = 96.485335 \text{ kJ mol}^{-1}$
Foot	$1 \text{ ft} = 12 \text{ in} = 0.3048 \text{ m}$ (exactly)
Gallon (U. S.)	$1 \text{ gallon} = 4 \text{ quarts} = 3.785412 \text{ L}$ (exactly)
Liter	$1 \text{ L} = 10^{-3} \text{ m}^3 = 10^3 \text{ cm}^3$ (exactly)
Liter-atmosphere	$1 \text{ L atm} = 101.325 \text{ J}$ (exactly)
Metric ton	$1 \text{ t} = 1000 \text{ kg}$ (exactly)
Pound	$1 \text{ lb} = 16 \text{ oz} = 0.4539237 \text{ kg}$ (exactly)
Rydberg	$1 \text{ Ry} = 2.17987197 \times 10^{-18} \text{ J} = 1312.7136 \text{ kJ mol}^{-1} = 13.60569193 \text{ eV}$
Standard atmosphere	$1 \text{ atm} = 1.01325 \times 10^5 \text{ Pa} = 1.01325 \times 10^5 \text{ kg m}^{-1} \text{ s}^{-2}$ (exactly)
Torr	$1 \text{ torr} = 133.3224 \text{ Pa}$

PERIODIC TABLE OF THE ELEMENTS

<http://www.kjf-split.in/periodictable/>

GROUP	PERIOD																GROUP																
1																	18																
IA																	VIIIA																
1	1.0079 H HYDROGEN	2																	2	4.0026 He HELIUM													
2	6.941 Li LITHIUM	3	9.0122 Be BERYLLIUM															10	20.180 Ne NEON														
3	22.990 Na SODIUM	4	24.305 Mg MAGNESIUM	5	26.982 Al ALUMINIUM	6	12.011 C CARBON	7	14.007 N NITROGEN	8	15.999 O OXYGEN	9	18.998 F FLUORINE	10	35.453 Cl CHLORINE	11	39.948 Ar ARGON																
4	39.098 K POTASSIUM	5	40.078 Ca CALCIUM	6	50.942 V VANADIUM	7	58.933 Cr CHROMIUM	8	55.845 Mn MANGANESE	9	58.933 Fe IRON	10	58.933 Co COBALT	11	58.933 Ni NICKEL	12	63.546 Cu COPPER	13	65.39 Zn ZINC	14	69.723 Ga GALLIUM	15	72.64 Ge GERMANIUM	16	74.922 As ARSENIC	17	78.96 Se SELENIUM	18	79.904 Br BROMINE	19	83.80 Kr KRYPTON		
5	85.468 Rb RUBIDIUM	6	87.62 Sr STRONTIUM	7	91.224 Zr ZIRCONIUM	8	92.906 Nb NIOBIUM	9	95.94 Mo MOLYBDENUM	10	98 Tc TECHNETIUM	11	101.07 Ru RUTHENIUM	12	102.91 Rh RHODIUM	13	106.42 Pd PALLADIUM	14	107.87 Ag SILVER	15	112.41 Cd CADMIUM	16	114.82 In INDIUM	17	118.71 Sn ANTIMONY	18	121.76 Sb TELLESIUM	19	127.60 Te TELLURIUM	20	126.90 I IODINE	21	131.29 Xe XENON
6	132.91 Cs CAESIUM	7	137.33 Ba BARIUM	8	178.49 Hf HAFNIUM	9	180.95 Ta TANTALUM	10	183.84 W TUNGSTEN	11	186.21 Re RHENIUM	12	186.23 Os OSMIUM	13	192.22 Ir IRIDIUM	14	195.08 Pt PLATINUM	15	196.97 Au GOLD	16	200.59 Hg MERCURY	17	204.38 Tl THALLIUM	18	207.2 Pb LEAD	19	208.98 Bi BISMUTH	20	209 Po POLONIUM	21	210 At ASTATINE	22	222 Rn RADON
7	223 Fr FRANCIUM	8	226 Ra RADIUM	9	227 Ac ACTINIDE																												



(1) Pure Appl. Chem., 73, No. 4, 867-883 (2001)

Relative atomic mass is shown with the significant figures. For elements with no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.

However, these such elements (Th, Pa, and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.

Editor: Aditya Vardhan (advtor@rediffmail.com)

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LANTHANIDE																													
57	138.91 La LANTHANUM	58	140.12 Ce CERIUM	59	140.91 Pr PRASEODYMIUM	60	144.24 Nd NEODYMIUM	61	145 Pm PROMETHIUM	62	150.36 Sm SAMARIUM	63	151.96 Eu EUROPIUM	64	157.25 Gd GADOLINIUM	65	158.93 Tb TERBIUM	66	162.50 Dy DYSPROSIUM	67	164.93 Ho HOLMIUM	68	167.26 Er ERBIUM	69	168.93 Tm THULIUM	70	173.04 Yb YTERBIUM	71	174.97 Lu LUTETIUM
ACTINIDE																													
89	227 Ac ACTINIUM	90	232.04 Th THORIUM	91	231.04 Pa PROTACTINIUM	92	238.03 U URANIUM	93	237 Np NEPTUNIUM	94	244 Pu PLUTONIUM	95	243 Am AMERICIUM	96	247 Cm CURIUM	97	247 Bk BERKELIUM	98	251 Cf CALIFORNIUM	99	252 Es EINSTEINIUM	100	257 Fm FERMIUM	101	258 Md Mendelevium	102	259 No NOBELIUM	103	262 Lr LAWRENCIUM

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		Yes: <input type="checkbox"/>	No: <input type="checkbox"/>
		Pts (+/-)	Reasons