

Chem 202

FINAL EXAM

April 29, 2017

Dr. Hoyt MWF 9:00 202-01	Dr. Kuta TTh 11:00 202-02	Dr. Noble TTh 2:30 202-03	Dr. Franco 202-50 online	Dr. Kuta TTh 5:30 202-75
A Th 8:00	A W 8:00	A M 9:00		A Th 4:30
B T 12:00	B F 1:00	B M 10:00		B Th 7:00
C T 1:00	C T 9:00	C T 11:00		C T 7:00
D Th 10:00	D W 9:00	D W 8:00		D T 4:30
E Th 1:00	E Th 9:00	E W 12:00		E T 7:00
F M 8:00	F F 12:00	F Th 4:00		F Th 7:00

This exam will be graded by the SCANTRON Form provided. Be certain that you fill it in correctly. On the front side in the spaces as shown below, enter your name (print and sign), enter your lecture 202-number (01, 02, 03, 50 or 75), and enter your recitation section letter. See the above list.

NAME print your name and sign your name
SUBJECT give 202-number (01, 02, 03, 50 or 75) TEST NO. give section letter
DATE _____ PERIOD _____

On the back side of the Form in the colored portion where it says "NAME", print your last name. **BE CERTAIN TO ENTER THE CORRECT INFORMATION.**

This exam has 35 questions. Part 1 has 15 questions worth four points each and covers newer material; this Part must be answered on the FRONT side of the SCANTRON Form in spaces 1-15. Part 2 has 20 questions worth two points each and covers older material; this Part must be answered on the BACK side of the SCANTRON Form in spaces 26-45. Because of this arrangement, **THERE ARE NO QUESTIONS NUMBERED 16-25.** Skip 16-25 on the SCANTRON Form.

Be certain no stray marks are on the Form. Be certain you fill in all spaces properly. Be certain you cleanly erase any changes. You must use a pencil.

For every question there is only one correct answer. Be certain you have all questions 1-15 and 26-45.

None of the exam pages will be collected. You may tear pages off. **TURN IN ONLY THE SCANTRON CARD.** Give the card to your (or another) TA in the room. Have your picture ID ready.

The key for the exam will be posted shortly afterwards at noblereaction.org/gc/202misc.htm. If you record your answers, you will be able to grade your exam.

NOTE: Due to the various ways of solving some problems, answers can differ by ± 1 in the final significant digit. Be aware of this.

General Constants $\text{mol} = 6.022 \times 10^{23}$
 $R = 0.08206 \text{ L} \cdot \text{atm}/(\text{mol} \cdot \text{K}) = 8.314 \text{ J}/(\text{mol} \cdot \text{K})$
 $T(\text{K}) = T(^{\circ}\text{C}) + 273$

Free Energy $\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ}$
 $\Delta G = \Delta G^{\circ} + RT \ln Q$
 $\Delta G^{\circ} = -RT \ln K$

Quadratic Equation $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

K_a Value $\text{CH}_3\text{CO}_2\text{H} \quad 1.8 \times 10^{-5}$

Henderson-Hasselbalch $\text{pH} = \text{p}K_a + \log \frac{\text{base}}{\text{acid}}$

Electrochemical $\Delta G^{\circ} = -nFE^{\circ}$
 $F = 96,485 \text{ C/mol}$ $A = \text{C/s}$
 $E = E^{\circ} - \frac{0.0257 \text{ V}}{n} \ln Q$

Nuclear $y = 365.24 \text{ d}$ $\text{Ci} = 3.7 \times 10^{10} \text{ Bq}$
 $c = 3.00 \times 10^8 \text{ m/s}$ $J = \text{kg} \cdot \text{m}^2/\text{s}^2$
 $A = \lambda N$ $t_{1/2} = \frac{\ln 2}{\lambda}$
 $\ln \frac{N_0}{N_t} = \ln \frac{A_0}{A_t} = \lambda t$
 $E = mc^2$

Masses ${}^4\text{He} \quad 4.002603$ ${}^{14}\text{C} \quad 14.003242$
 ${}^{294}\text{Og} \quad 294.213921$ ${}^{290}\text{Lv} \quad 290.198638$ ${}^{294}\text{Ts} \quad 294.210462$

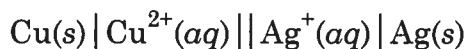
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Part 1. Newer Material

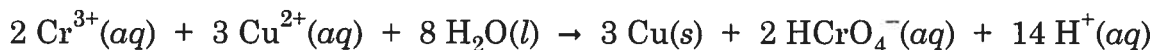
- Which statement below is FALSE regarding electrochemical reactions?
 - A redox reaction must include both an oxidation and a reduction.
 - In a balanced redox reaction equation, the total charges on both sides of the equation must be zero.
 - In a balanced redox reaction equation, both the atoms and the charges must be balanced.
 - At equilibrium, $E = 0$.
 - A galvanic cell becomes an electrolytic cell when the same reaction is run in reverse.
- Consider the reaction of metallic iron with sulfate ion in acidic solution to produce iron(III) ion and sulfur dioxide gas. In the balanced equation with smallest, whole-number coefficients, how many $\text{H}^+(\text{aq})$ ions are present?
 - 4
 - 6
 - 8
 - 10
 - 12

- A galvanic cell is prepared using copper and silver. Its cell notation is below.



Which of the following processes occurs at the cathode?

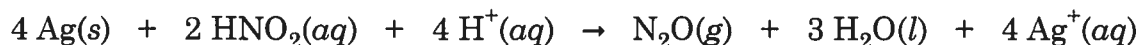
- $\text{Cu}(s) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2 e^-$
 - $\text{Cu}^{2+}(\text{aq}) + 2 e^- \rightarrow \text{Cu}(s)$
 - $\text{Ag}(s) \rightarrow \text{Ag}^+(\text{aq}) + e^-$
 - $\text{Ag}^+(\text{aq}) + e^- \rightarrow \text{Ag}(s)$
 - $\text{Cu}(s) + 2 \text{Ag}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2 \text{Ag}(s)$
- Consider the following balanced equation.



Calculate E° (in V).

- 1.69
- 1.01
- 0.15
- 1.01
- 1.69

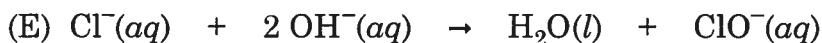
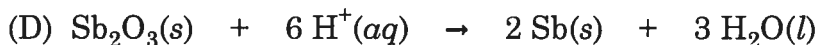
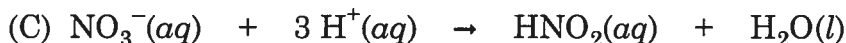
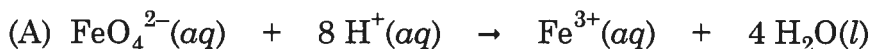
5. Consider the reaction represented by the (balanced) equation below, which occurs in acidic solution. For this reaction, $E^\circ = +0.50 \text{ V}$.



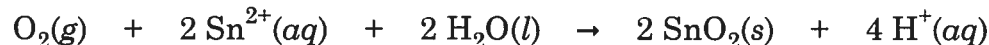
Which of the following statements regarding this reaction is FALSE?

- (A) If the concentration of HNO_2 is increased, the value of E will be greater.
(B) Elemental silver is the reducing agent in the reaction.
(C) Decreasing the concentration of Ag^+ will increase the value of E .
(D) Hydrogen is reduced in this reaction.
(E) One of the two half-cells requires an inert electrode.
6. For the reaction given in Problem 5, calculate the value of ΔG° (in kJ).
- (A) -190 (B) -48 (C) -22 (D) 0.50 (E) 230

7. Each of the following represents either a reduction or an oxidation half-reaction; the equations are atom-balanced, but the number of electrons is missing. Which entry below is for oxidation with $n = 3$?



8. Consider the following cell reaction.



Which one of the following processes will not change E of the cell?

- (A) Add more $\text{SnO}_2(s)$ to the anode compartment.
(B) Dilute the anode compartment with more water.
(C) Increase the pressure of $\text{O}_2(g)$ in the cathode compartment.
(D) Decrease the pH in the anode compartment.
(E) Increase the concentration of $\text{Sn}^{2+}(aq)$ in the anode compartment.

9. How much time (in s) is needed to electroplate 0.0240 g of gold metal from a solution of $\text{Au}^{3+}(\text{aq})$, using a current of 0.0500 A?
- (A) 235 (B) 538 (C) 705 (D) 1,320 (E) 2,120
10. Which of the following statements is FALSE?
- (A) All nuclides with $N = Z$ are stable.
 (B) ^{230}Th is a radionuclide.
 (C) The daughter of an alpha decay is always of lower atomic number than the parent.
 (D) γ -decay is due to nuclear relaxations.
 (E) Proton-proton repulsion can be overcome at short distance by the strong force.
11. Which nuclear decay process is occurring when ^{234}Th decays to produce ^{234}Pa ?
- (A) alpha decay (B) electron capture (C) gamma emission
 (D) beta negative (β^-) emission (E) positron (β^+) emission
12. Which one of the following equations correctly represents electron capture by $^{204}_{84}\text{Po}$?
- (A) $^{204}_{84}\text{Po} \rightarrow ^{204}_{85}\text{At} + ^0_{-1}\beta$ (B) $^{204}_{84}\text{Po} \rightarrow ^{204}_{83}\text{Bi} + ^0_1\beta$
 (C) $^{204}_{84}\text{Po} + ^0_1\beta \rightarrow ^{204}_{85}\text{At}$ (D) $^{204}_{84}\text{Po} + ^0_{-1}\text{e} \rightarrow ^{204}_{85}\text{At}$
 (E) $^{204}_{84}\text{Po} + ^0_{-1}\text{e} \rightarrow ^{204}_{83}\text{Bi}$
13. 1.20×10^{-6} g of ^{14}C undergoes β^- decay with $t_{1/2} = 5.70 \times 10^3$ years. What is the activity (in Bq)?
- (A) 1.75×10^5 (B) 1.99×10^5 (C) 2.13×10^5 (D) 2.32×10^5 (E) 2.57×10^5

14. ^{67}Cu is used in nuclear medicine for radiotherapy. It decays by β^- emission with a half-life of 61.8 hours. For a sample with an initial activity of $50.0\ \mu\text{Ci}$, what is the activity (in μCi) after 384 hours?
- (A) 0.401 (B) 0.527 (C) 0.674 (D) 0.748 (E) 0.812
15. One of the newest elements is oganesson (Og), $Z = 118$. ^{294}Og decays by alpha emission with a half-life of 1.4 ms. How much energy (in GJ) is released for one mole of this decay?
- (A) 371 (B) 588 (C) 742 (D) 983 (E) 1,140

**16-25: LEAVE THESE SPACES BLANK ON THE SCANTRON CARD.
GO TO NUMBER 26 ON THE BACKSIDE OF THE CARD.**

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Part 2. Older Material

26. Which of the following statements is TRUE?
- (A) For one mole of a given substance at standard conditions, the entropy of vaporization is greater than the entropy of sublimation.
- (B) At the freezing point, water has zero EVP.
- (C) Sublimation and deposition cannot be in equilibrium above the triple point temperature.
- (D) $\Delta H_{\text{vap}}^\circ$ can be positive or negative.
- (E) Boron trifluoride is an ionic network compound.
27. Which of the following statements is FALSE?
- (A) The dipole-dipole interaction involves the permanent dipoles of polar molecules.
- (B) Increasing molecular polarity always decreases the strength of dispersion.
- (C) H_2Se has stronger dispersion than H_2S .
- (D) AsCl_3 has a higher boiling point than AsF_3 .
- (E) At $25\ ^\circ\text{C}$, ClF_3 has a higher EVP than BrF_3 .

28. Given that the enthalpy of sublimation of I_2 at $25\text{ }^\circ\text{C}$ is 62.42 kJ , how many kilojoules are needed to sublime 50.0 g of I_2 at that temperature?

- (A) 12.3 (B) 16.7 (C) 23.8 (D) 28.0 (E) 30.6

29. Consider separate, aqueous solutions of each of the following.



Two of these compounds can do hydrogen bonding as a primary interaction with water. Which two?

- (A) CH_4 and H_2CF_2 (B) H_2CF_2 and HN_3 (C) HN_3 and HOCl
(D) HOCl and PH_3 (E) PH_3 and SF_6

30. Which of the following statements is FALSE?

- (A) Calcium chloride does ion-dipole interaction with water.
(B) Ammonia does hydrogen bonding with water.
(C) In water, the dipole-induced dipole interaction is better for CH_4 than for C_2H_6 .
(D) For a substance dissolving into water, a negative $\Delta H^\circ_{\text{soln}}$ favors dissolving.
(E) For a substance dissolving into water, a positive $\Delta S^\circ_{\text{soln}}$ favors dissolving.

31. In which line below are both entries always correct for the conditions indicated?

	Standard Conditions	Equilibrium Conditions
(A)	$\Delta G^\circ = 0$	$\Delta G = \Delta G^\circ$
(B)	$\Delta G = \Delta G^\circ$	$\Delta G^\circ = 0$
(C)	$Q = 1$	$Q = K$
(D)	$Q = K$	$K = 1$
(E)	$Q = K$	$\Delta G = 0$

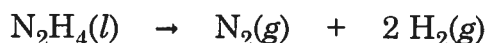
32. Consider the following equation,



for which $\Delta H^\circ = +851.5 \text{ kJ}$ and $\Delta S^\circ = +38.5 \text{ J/K}$. Calculate the value of ΔG° (in kJ) for this reaction at 600. °C.

- (A) -22,200 (B) 817.9 (C) 851.5 (D) 1,102.6 (E) 1,803.3

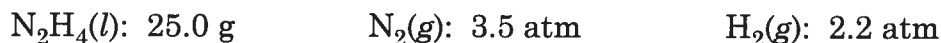
33. The following reaction,



has $\Delta H^\circ = -50.6 \text{ kJ}$ and $\Delta S^\circ = +331.5 \text{ J/K}$. Based on this information, what can we predict about the spontaneity of the reaction?

- (A) The reaction is not spontaneous at any temperature.
(B) The reaction is not spontaneous at low temperature, but is spontaneous at high temperature.
(C) The reaction is spontaneous at low temperature, but is not spontaneous at high temperature.
(D) The reaction is spontaneous at all temperatures.
(E) There's not enough information to make a prediction.

34. For the reaction in Problem 33, $\Delta G^\circ = -142.1 \text{ kJ}$ at 276 K. Calculate the value of ΔG (in kJ) when the following amounts of reactants and products are present.



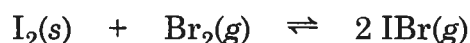
- (A) -111.7 (B) -117.6 (C) -123.0 (D) -129.9 (E) -135.6

35. Which of the reactions below will have the most negative value of ΔS° ?

- (A) $\text{Cr}_2\text{O}_3(s) + 2 \text{Al}(s) \rightarrow 2 \text{Cr}(s) + \text{Al}_2\text{O}_3(s)$
(B) $2 \text{Cr}_2\text{O}_3(s) \rightarrow 4 \text{Cr}(s) + 3 \text{O}_2(g)$
(C) $2 \text{PbS}(s) + 5 \text{O}_2(g) \rightarrow 2 \text{PbO}_2(s) + 2 \text{SO}_3(g)$
(D) $\text{PbO}_2(s) + \text{S}(s) \rightarrow \text{PbS}(s) + \text{O}_2(g)$
(E) $\text{HCl}(g) + \text{CN}^-(aq) \rightarrow \text{HCN}(g) + \text{Cl}^-(aq)$

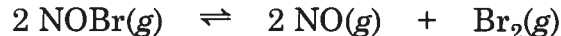
36. Which of the following statements is FALSE regarding a catalyst?
- (A) A catalyst speeds up a process in both the forward and reverse directions.
 (B) A catalyst lowers the activation energy of one or more steps of the process.
 (C) A catalyst speeds up a process by changing its mechanism.
 (D) A catalyst lowers ΔH of the reaction.
 (E) A catalyst does not appear in the overall reaction.

37. Consider the following reaction, for which $K = 0.027$ at 273 K.



The reaction starts with 0.080 atm $\text{Br}_2(\text{g})$ and an excess amount of $\text{I}_2(\text{s})$. What is the pressure of $\text{Br}_2(\text{g})$ (in atm) at equilibrium?

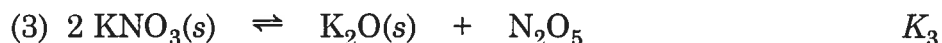
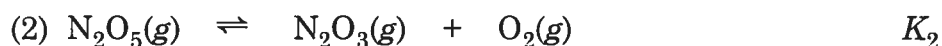
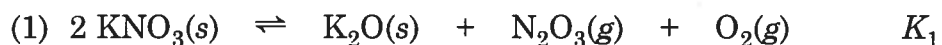
- (A) 0.027 (B) 0.033 (C) 0.041 (D) 0.055 (E) 0.060
38. The following reaction is second order in NOBr, with $k = 0.405 \text{ 1}/(\text{M} \cdot \text{s})$ at 10. °C.



For a concentration of NOBr equal to 0.500 M, what is the rate (in M/s)?

- (A) 0.101 (B) 0.202 (C) 0.303 (D) 0.404 (E) 0.505
39. For a single elementary step with $E_{\text{a, fwd}} = 80. \text{ kJ}$ and $\Delta H = -20. \text{ kJ}$, what is $E_{\text{a, rev}}$ (in kJ)?
- (A) 20. (B) 60. (C) 80. (D) 100. (E) 120.

40. Consider the following reactions with their respective K values.



What combination of K_1 and K_2 will produce K_3 ?

- (A) $K_1 \times K_2$ (B) $K_1 - K_2$ (C) K_2/K_1 (D) $K_2 - K_1$ (E) K_1/K_2

41. A solution is prepared by dissolving sodium fluoride, NaF, into water. Which statement about the solution is TRUE?
- (A) The solution is basic.
 (B) The solution has $\text{pOH} = \text{pH}$.
 (C) The pH of the solution is less than 7.00.
 (D) The concentration of fluoride ions and sodium ions will be identical at equilibrium.
 (E) The concentration of fluoride ions will be greater than the concentration of sodium ions at equilibrium.
42. How many of the following examples represent conjugate acid/base pairs?
 $\text{H}_3\text{O}^+/\text{H}_2\text{O}$ $\text{NH}_4^+/\text{NH}_3$ $\text{OH}^-/\text{O}^{2-}$ $\text{H}_2\text{PO}_4^-/\text{HPO}_4^{2-}$ HCl/H^+
- (A) 1 (B) 2 (C) 3 (D) 4 (E) 5
43. A 0.050 M solution of a weak acid, HA, has $[\text{H}^+] = 3.77 \times 10^{-4}$ M at equilibrium. What is the value of K_a for the acid?
- (A) 7.5×10^{-3} (B) 2.8×10^{-6} (C) 7.0×10^{-7} (D) 7.0×10^{-8} (E) 2.6×10^{-11}
44. A buffer is prepared by combining 0.600 mol of NaCH_3CO_2 and 0.400 mol $\text{CH}_3\text{CO}_2\text{H}$ in 1.00 L of solution volume. What is the pH of this buffer?
- (A) 4.52 (B) 4.59 (C) 4.87 (D) 4.92 (E) 4.97
45. Which of the following is the solubility product expression for silver sulfide, Ag_2S ?
- (A) $[\text{Ag}^+][\text{S}^{2-}]$ (B) $[\text{Ag}^+][\text{S}^{2-}]^2$ (C) $[\text{Ag}^+]^2[\text{S}^{2-}]$
 (D) $\frac{[\text{Ag}^+][\text{S}^{2-}]^2}{[\text{Ag}_2\text{S}(s)]}$ (E) $\frac{1}{[\text{Ag}^+][\text{S}^{2-}]^2}$