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**FINAL EXAM – FORM B**

9 June 2009

Chem 1B

Instructor: Ortony

**INSTRUCTIONS:**

Use a pencil, fill in the bubbles dark and completely.

Bubble in **Form B** on your Scantron Form

Write your perm number and **bubble in your perm number**, write your name.

Work out the answer to each problem on this exam then bubble in the correct answer on your scantron. **Turn in BOTH the Scantron form and the exam.**

The equation sheet is on the last page, you may remove it from your exam.

The key to the exam will be posted on the course webpage this afternoon.

Exam scores will be posted on “Online Grades”. To access your grade you must create an account first, there is a link on our course webpage (everyone in Chem 1B must create an account – even if you already did so in the past).

**CHEM 1B FINAL EXAM – FORM B**  
**SPRING 2009 - ORTONY**

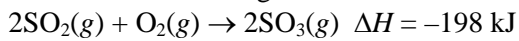
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*Last name*

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1. One mole of an ideal gas is expanded from a volume of 1.50 L to a volume of 10.18 L against a constant external pressure of 1.03 atm. Calculate the work.
  - A)  $-8.79 \times 10^2$  J
  - B)  $-9.06 \times 10^2$  J
  - C)  $-8.94$  J
  - D)  $-0.0883$  J
  - E)  $9.06$  J
  
2. Calculate the work for the expansion of an ideal gas from 3.5 to 5.4 L against a pressure of 2.2 atm at constant temperature.
  - A)  $-0.9$  L•atm
  - B)  $4.2$  L•atm
  - C)  $-4.2$  L•atm
  - D) 0
  - E)  $4.0$  L•atm
  
3. Calculate  $\Delta E$  for a system that releases 24 J of heat while 57 J of work is done on it.
  - A) 24 J
  - B)  $-81$  J
  - C) 81 J
  - D)  $-33$  J
  - E) 33 J

4. Consider the following reaction:



Calculate the energy change associated with 23.8 g of  $\text{SO}_2$  reacting with excess  $\text{O}_2$ .

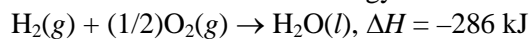
- A) -36.8 kJ
- B) -73.5 kJ
- C) -147 kJ
- D)  $-4.71 \times 10^3$  kJ
- E) -198 kJ

5.  $\text{CH}_4 + 4\text{Cl}_2(g) \rightarrow \text{CCl}_4(g) + 4\text{HCl}(g)$ ,  $\Delta H = -434$  kJ

Based on the above reaction, what energy change occurs when 1.5 mol of methane reacts?

- A)  $4.3 \times 10^2$  J is released.
- B)  $6.5 \times 10^5$  J is absorbed.
- C)  $2.9 \times 10^5$  J is released.
- D)  $2.9 \times 10^5$  J is absorbed.
- E)  $6.5 \times 10^5$  J is released.

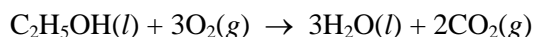
6. The total volume of hydrogen gas needed to fill the *Hindenburg* was  $2.00 \times 10^8$  L at 1.00 atm and  $25.0^\circ\text{C}$ . How much energy was evolved when it burned?



- A)  $3.5 \times 10^{11}$  kJ
- B)  $2.34 \times 10^9$  kJ
- C)  $2.86 \times 10^4$  kJ
- D)  $8.18 \times 10^6$  kJ
- E)  $5.72 \times 10^{10}$  kJ

7. A 22.4-g piece of aluminum (which has a molar heat capacity of  $24.03 \text{ J/mol}^\circ\text{C}$ ) is heated to  $84.8^\circ\text{C}$  and dropped into a calorimeter containing water (the specific heat capacity of water is  $4.18 \text{ J/g}^\circ\text{C}$ ) initially at  $22.8^\circ\text{C}$ . The final temperature of the water is  $27.0^\circ\text{C}$ . Calculate the mass of water in the calorimeter.
- A) 2.0 g  
B)  $7.0 \times 10^1 \text{ g}$   
C)  $1.8 \times 10^3 \text{ g}$   
D)  $6.6 \times 10^1 \text{ g}$   
E) 0.35 g

8. Using Hess's law and equations 1-3 below, find  $\Delta H^\circ$  at  $25^\circ\text{C}$  for the oxidation of  $\text{C}_2\text{H}_5\text{OH}(l)$ .



1.  $\text{C}_2\text{H}_4(g) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 2\text{H}_2\text{O}(l)$   $\Delta H^\circ = -1411 \text{ kJ}$   
2.  $\text{C}(\text{graphite}) + 3\text{H}_2(g) + (1/2)\text{O}_2(g) \rightarrow \text{C}_2\text{H}_5\text{OH}(l)$   $\Delta H^\circ = -278 \text{ kJ}$   
3.  $\text{C}_2\text{H}_4(g) + \text{H}_2\text{O}(l) \rightarrow \text{C}_2\text{H}_5\text{OH}(l)$   $\Delta H^\circ = -44 \text{ kJ}$

- A) 632 kJ  
B) -1367 kJ  
C) 44 kJ  
D) -1742 kJ  
E) none of these
9. The enthalpy of formation of an element in its standard state is
- A) zero.  
B) the enthalpy of its reaction with oxygen.  
C) determined by its melting point.  
D) the enthalpy of its reaction with hydrogen.  
E) none of these

10. Using the information below, calculate  $\Delta H^\circ_f$  for  $\text{PbO}(s)$ .
- $$\text{PbO}(s) + \text{CO}(g) \rightarrow \text{Pb}(s) + \text{CO}_2(g), \quad \Delta H^\circ = -131.4 \text{ kJ}$$
- $$\Delta H^\circ_f \text{ for } \text{CO}_2(g) = -393.5 \text{ kJ/mol}$$
- $$\Delta H^\circ_f \text{ for } \text{CO}(g) = -110.5 \text{ kJ/mol}$$
- A)  $-151.6 \text{ kJ/mol}$   
B)  $-372.6 \text{ kJ/mol}$   
C)  $+283.0 \text{ kJ/mol}$   
D)  $-283.0 \text{ kJ/mol}$   
E)  $+252.1 \text{ kJ/mol}$
11. Consider the process  $\text{A}(l) \rightleftharpoons \text{A}(s)$ . Which direction favors greater entropy of the system?  
A) to the left  
B) to the right  
C) neither
12. Consider the process  $\text{A}(l) \rightleftharpoons \text{A}(s)$ . An increase in temperature favors which direction?  
A) to the left  
B) to the right  
C) neither  
D) More information is needed.

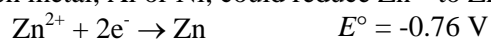
Use the following to answer questions 13 – 15:

At 1 atm, a liquid is heated above its normal boiling point.

13.  $\Delta S_{\text{surr}}$  for this process is  
A) less than zero.  
B) greater than zero.  
C) equal to zero.  
D) cannot be determined
14.  $\Delta S$  for this process is  
A) less than zero.  
B) greater than zero.  
C) equal to zero.  
D) cannot be determined

15.  $\Delta S_{\text{univ}}$  for this process is
- A) equal to zero.
  - B) less than zero.
  - C) greater than zero.
  - D) cannot be determined
16. 5.50 mol of a monatomic ideal gas is cooled from 246°C to 27°C at constant volume. Calculate  $\Delta S$ .
- A) -37.6 J/K
  - B) -27.2 J/K
  - C) -16.3 J/K
  - D) -62.7 J/K
  - E)  $-1.52 \times 10^2$  J/K
17. For the process involving compound A:  $A(s) \rightarrow A(l)$ ,  $\Delta H^\circ = 7.5$  kJ/mol, and  $\Delta S^\circ = 43.4$  J/mol•K. What is the melting point of compound A?
- A) 173°C
  - B) -100°C
  - C) -222°C
  - D) -173°C
  - E) 100°C
18. What is the oxidation state of Mn in  $\text{MnO}_2$ ?
- A) -1
  - B) +3
  - C) +4
  - D) +2
  - E) +9
19. How many electrons are transferred in the following reaction?
- $$2\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Cl}^- \rightarrow 2\text{Cr}^{3+} + 3\text{Cl}_2 + 7\text{H}_2\text{O}$$
- A) 2
  - B) 4
  - C) 6
  - D) 8
  - E) none of these

20. Which metal, Al or Ni, could reduce  $\text{Zn}^{2+}$  to  $\text{Zn}(s)$  if placed in a  $\text{Zn}^{2+}(aq)$  solution?



- A) Al
- B) Ni
- C) Both Al and Ni would work.
- D) Neither Al nor Ni would work.
- E) This cannot be determined.

Use the following to answer questions 21 - 23:

| Reaction  | $E^{\circ}$ (volts) |
|---|---------------------|
| $\text{Na}^{+} + e^{-} \rightarrow \text{Na}$     | -2.71               |
| $\text{Al}^{3+} + 3e^{-} \rightarrow \text{Al}$   | -1.66               |
| $\text{Fe}^{2+} + 2e^{-} \rightarrow \text{Fe}$   | -0.44               |
| $\text{Co}^{2+} + 2e^{-} \rightarrow \text{Co}$   | -0.28               |
| $\text{Cu}^{2+} + 2e^{-} \rightarrow \text{Cu}$   | +0.34               |
| $\text{Ag}^{+} + e^{-} \rightarrow \text{Ag}$     | +0.80               |
| $\text{Cl}_2 + 2e^{-} \rightarrow 2\text{Cl}^{-}$ | +1.36               |
| $\text{F}_2 + 2e^{-} \rightarrow 2\text{F}^{-}$   | +2.87               |

21. Which of the following would be the best reducing agent?

- A)  $\text{Cl}_2$
- B) Na
- C)  $\text{F}_2$
- D)  $\text{Na}^{+}$
- E)  $\text{F}^{-}$

22. Silver will spontaneously reduce which of the following?

- A)  $\text{Al}^{3+}$
- B)  $\text{Co}^{2+}$
- C)  $\text{Na}^{+}$
- D)  $\text{Fe}^{2+}$
- E) none of these

23. Determine the standard potential,  $E^\circ$ , of a cell that employs the reaction
- $$\text{Co} + \text{Ag}^+ \rightarrow \text{Co}^{2+} + \text{Ag}$$
- A) -1.08 V  
B) -0.52 V  
C) 1.08 V  
D) 1.88 V  
E) none of these
24. The standard potential for the reaction  $\text{Zn} + 2\text{Ag}^+ \rightarrow \text{Zn}^{2+} + 2\text{Ag}$  is 1.56 V. Given that the standard reduction potential for  $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$  is 0.80 V, determine the standard reduction potential for  $\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$ .
- A) -0.76 V  
B) 0.04 V  
C) -0.38 V  
D) 0.76 V  
E) none of these
25. An electrolytic cell process involves plating  $\text{Zr}(s)$  from a solution containing  $\text{Zr}^{4+}$ . If 8.28 amp is run through this mixture for 1.86 h, what mass of Zr is plated?
- A) 0.071 g  
B) 0.144 g  
C) 7.18 g  
D) 36.7 g  
E) none of these
26. The rate expression for a particular reaction is  $\text{Rate} = k[\text{A}][\text{B}]^2$ . If the initial concentration of B is increased from 0.1 M to 0.3 M, the initial rate will increase by which of the following factors?
- A) 4  
B) 3  
C) 6  
D) 9  
E) 27

Use the following to answer question 27:

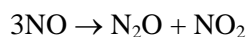
For the reaction  $2\text{N}_2\text{O}_5(\text{g}) \rightarrow 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$ , the following data were collected.

| $t$ (minutes) | $[\text{N}_2\text{O}_5]$ (mol/L) |
|---------------|----------------------------------|
| 0             | $1.24 \times 10^{-2}$            |
| 10.           | $0.92 \times 10^{-2}$            |
| 20.           | $0.68 \times 10^{-2}$            |
| 30.           | $0.50 \times 10^{-2}$            |
| 40.           | $0.37 \times 10^{-2}$            |
| 50.           | $0.28 \times 10^{-2}$            |
| 70.           | $0.15 \times 10^{-2}$            |

27. The half-life of this reaction is approximately

- A) 36 min
- B) 18 min
- C) 45 min
- D) 23 min
- E) 15 min

28. The reaction



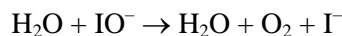
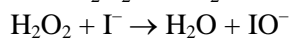
is found to obey the rate law  $\text{Rate} = k[\text{NO}]^2$ . If the first half-life of the reaction is found to be 4.4 s, what is the length of the fourth half-life?

- A) 8.3 s
- B) 66 s
- C) 70 s
- D) 26 s
- E) 18 s

29. The rate constant for a reaction increases from  $10.0 \text{ s}^{-1}$  to  $100. \text{ s}^{-1}$  when the temperature is increased from 317 K to 427 K. What is the activation energy for the reaction in kJ/mol?

- A) 0.0756 kJ/mol
- B) 10.2 kJ/mol
- C) 1.74 kJ/mol
- D) 21.1 kJ/mol
- E) 23.6 kJ/mol

30. The reaction  $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$  has the following mechanism:



What is the catalyst in the reaction?

- A)  $\text{H}_2\text{O}$   
B)  $\text{H}_2\text{O}_2$   
C)  $\text{I}^-$   
D)  $\text{IO}^-$
31. Which of the following frequencies corresponds to light with the longest wavelength?  
A)  $4.12 \times 10^5 \text{ s}^{-1}$   
B)  $3.00 \times 10^{13} \text{ s}^{-1}$   
C)  $8.50 \times 10^{20} \text{ s}^{-1}$   
D)  $3.20 \times 10^9 \text{ s}^{-1}$   
E)  $9.12 \times 10^{12} \text{ s}^{-1}$
32. A photographic film needs a minimum of 80.0 kJ/mol for exposure. What is the longest wavelength of radiation with sufficient energy to expose the film?  
A)  $1.50 \times 10^{-3} \text{ m}$   
B)  $1.50 \times 10^{-12} \text{ m}$   
C)  $1.50 \times 10^{-6} \text{ m}$   
D)  $1.50 \times 10^{-9} \text{ m}$   
E) none of these
33. Consider an atom traveling at 1% of the speed of light. The de Broglie wavelength is found to be  $3.31 \times 10^{-3} \text{ pm}$ . Which element is this? (\*hints\*  $\lambda = h/mv$  and  $1 \text{ pm} = 1 \times 10^{-12} \text{ m}$ )  
A) Be  
B) He  
C) F  
D) P  
E) Ca
34. What is the wavelength of light that is emitted when an excited electron in the hydrogen atom falls from the  $n = 5$  level to the  $n = 2$  level?  
A)  $5.12 \times 10^{-7} \text{ m}$   
B)  $5.82 \times 10^{-7} \text{ m}$   
C)  $6.50 \times 10^{-7} \text{ m}$   
D)  $4.34 \times 10^{-7} \text{ m}$   
E) none of these

Use the following to answer questions 35 -36:

Consider the following portion of the energy-level diagram for hydrogen:

$$n = 4 \quad -0.1361 \times 10^{-18} \text{ J}$$

$$n = 3 \quad -0.2420 \times 10^{-18} \text{ J}$$

$$n = 2 \quad -0.5445 \times 10^{-18} \text{ J}$$

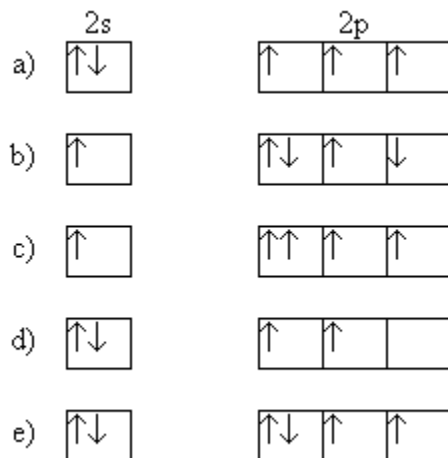
$$n = 1 \quad -2.178 \times 10^{-18} \text{ J}$$

35. For which of the following transitions does the light emitted have the longest wavelength?
- A)  $n = 4$  to  $n = 3$
  - B)  $n = 4$  to  $n = 2$
  - C)  $n = 4$  to  $n = 1$
  - D)  $n = 3$  to  $n = 2$
  - E)  $n = 2$  to  $n = 1$
36. In the hydrogen spectrum, what is the wavelength of light associated with the  $n = 2$  to  $n = 1$  electron transition?
- A)  $9.122 \times 10^{-8} \text{ m}$
  - B)  $1.216 \times 10^{-7} \text{ m}$
  - C)  $0.1097 \times 10^{-8} \text{ cm}$
  - D)  $1.097 \text{ nm}$
  - E)  $364.9 \text{ nm}$

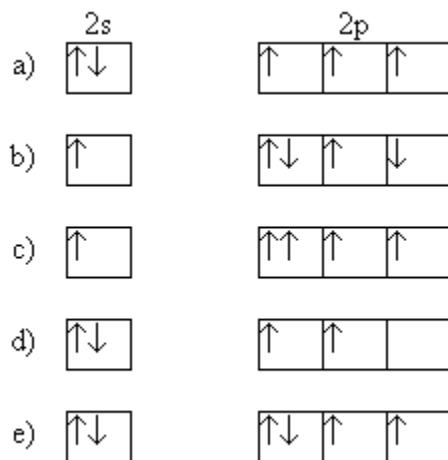
37. Which of the following is *not* determined by the principal quantum number,  $n$ , of the electron in a hydrogen atom?
- A) the energy of the electron
  - B) the minimum wavelength of the light needed to remove the electron from the atom.
  - C) the shape of the corresponding atomic orbital(s)
  - D) the size of the corresponding atomic orbital(s)
  - E) All of the above are determined by  $n$ .
38. What is the electron configuration for the barium atom?
- A)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
  - B)  $[\text{Xe}] 6s^2$
  - C)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
  - D)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
  - E) none of these
39. In which groups do all the elements have the same number of valence electrons?
- A) P, O, Cl
  - B) Ag, Cd, Ar
  - C) Na, Ca, Ba
  - D) N, P, As
  - E) P, As, Se
40. Of the following elements, which needs 3 electrons to complete its valence shell?
- A) P
  - B) K
  - C) Si
  - D) Ba
  - E) Cl
41. How many unpaired electrons are there in an atom of sulfur in its ground state?
- A) 0
  - B) 1
  - C) 2
  - D) 3
  - E) 4
42. Place the elements C, N, and O in order of increasing ionization energy.
- A) C, N, O
  - B) O, N, C
  - C) C, O, N
  - D) N, O, C
  - E) none of these

43. Which element is most likely to form an ion with a charge of 2+?
- A) Br
  - B) B
  - C) K
  - D) O
  - E) Mg

44. Which represents the ground state for N?



45. Which represents the ground state for the  $N^-$  ion?



*Have a nice summer!*