Directions: (1) Put your name (neatly) and signature on both parts of the exam where indicated.
(2) Each multiple choice question is actually 2 questions on your scanning sheet. If you are sure of an answer, put the same answer down for both questions for 5 pts. If you cannot decide between two answers, put one answer down for one question and the other answer down for the other question. If you get one correct you'll get half credit for 2.5 pts. If there is an ambiguous multiple choice question, use the last page to explain your answer.
(3) Do NOT write on the envelope.
(4) When finished, put both parts of the exam in the envelope with the scanning sheet. You can leave during announced times. You can pick up your multiple choice and answers outside my office after the exam.
(5) There are a total of 54 questions (29 actual questions).

**PART 1**

1&2. Which of the following elemental formulas could be the one for 3,3,4-trimethylhexane?

(a) C₉H₁₈  (b) C₉H₂₀  (c) C₇H₁₆  (d) C₈H₁₈  (e) C₆H₁₄

3&4. Which is the correct $K_c$ expression for the equilibrium: $P_4(s) + 6H_2(g) \rightleftharpoons 4PH_3(g)$?

(a) $K_c = \frac{[PH_3]^4}{[P_4][H_2]^6}$  (b) $K_c = \frac{[PH_3]^4}{[P_4][H_2]^6}$  (c) $K_c = \frac{[P_4][H_2]^6}{[PH_3]^4}$

(d) $K_c = \frac{[PH_3]^4}{[H_2]^6}$  (e) $K_c = \frac{4[PH_3]}{6[H_2]}$

5&6. Which of the following salts is the LEAST soluble?

(a) CdCO₃  (b) CoCO₃  (c) AgCl  (d) PbSO₄  (e) ZnCO₃
7&8. Which of the following statements is FALSE?

(a) Endothermic processes are those with $\Delta H > 0$.
(b) $\Delta H$ is a state function.
(c) Some spontaneous processes are endothermic.
(d) Entropy alone determines the spontaneity of a reaction.
(e) $\Delta G$ represents the free energy change for a process.

9&10. Which functional group is NOT present in the compound, zingerone, one of the compounds found in ginger.

(a) aldehyde  (b) phenol  (c) ether  (d) ketone  (e) all are found

11&12. Consider the gas-phase equilibrium system represented by the equation:

$$2 \text{NO}_2 \rightleftharpoons 2 \text{NO} + \text{O}_2$$

Given that the reaction is endothermic, as written, which of the following changes will decrease the equilibrium amount of NO$_2$?

(a) adding more oxygen
(b) increasing the pressure at constant temperature by decreasing the volume
(c) increasing the temperature at constant pressure
(d) adding a solid phase catalyst
(e) none of these

13&14. Of the following species, which is the STRONGEST oxidizing agent?

(a) V  (b) Au$^{3+}$  (c) Sn$^{2+}$  (d) Cu  (e) Co$^{2+}$
15&16. Consider the conversion of a substance between liquid and gas: liquid $\rightarrow$ gas. When the two phases are in equilibrium at one atmosphere pressure and at the boiling point of the substance,

(a) $\Delta E = 0$ for the process.
(b) $\Delta H = 0$ for the process.
(c) $\Delta G = 0$ for the process.
(d) $\Delta S = 0$ for the process.
(e) both (a) and (b)

17&18. For electrolysis of aqueous copper(II) bromide with the following observations, which of the following statements is incorrect?

Observation #1: one electrode become coated with copper metal
Observation #2: around the other electrode, the solution turns brown as molecular bromine is formed and dissolves.

(a) Reaction at the anode: $\text{Cu} \rightarrow \text{Cu}^{2+} + 2e^-$. 
(b) Reduction occurs at the electrode where Cu metal is being produced.
(c) Bromine molecules are produced at the electrode where oxidation is occurring.
(d) Electrons will flow through the external circuit from the anode to the cathode.
(e) The electrode where bromine molecules are produced is negatively charged.

19&20. Consider the following gas phase reaction: $A + 2B \rightarrow AB_2$
occurs by the following mechanism:

Step 1  $A + B \rightarrow AB$  slow
Step 2  $AB + B \rightarrow AB_2$  fast
Overall  $A + 2B \rightarrow AB_2$

The rate law expression must be Rate = ________.

(a) $k[A]$  (b) $k[B]$  (c) $k[A][B]^2$  (d) $k[B]^2$  (e) $k[A][B]$

21&22. A particular reaction $X + 3Y \rightarrow 2Z + W$ releases 25 kJ of heat and has an activation energy for the forward reaction of 30 kJ. Sketch a potential energy diagram for this reaction. What is the activation energy for the reverse reaction?.

(a) 25 kJ  (b) 30 kJ  (c) 5 kJ  (d) 55 kJ  (e) 45 kJ
23&24. Consider 0.1 M solutions of the following weak acids:

\[
\begin{align*}
\text{CH}_3\text{COOH} & \quad K_a = 1.8 \times 10^{-5} \\
\text{HBrO} & \quad K_a = 2.5 \times 10^{-9}
\end{align*}
\]

Which of the following statements is NOT correct?

(a) Acetic acid is a stronger acid than hypobromous acid.
(b) The concentration of OH\(^-\) ions is greater in the HBrO solution.
(c) \([\text{BrO}^-]\) in HBrO solution > \([\text{CH}_3\text{COO}^-]\) in CH\(_3\text{COOH}\) solution.
(d) \([\text{H}^+]\) in CH\(_3\text{COOH}\) solution > \([\text{H}^+]\) in HBrO solution.
(e) The pH of the CH\(_3\text{COOH}\) solution is lower than the pH of the HBrO solution.

25&26. What is the pH of a 6.2 \times 10^{-4} M KOH?

(a) 2.95 (b) 3.39 (c) 9.55 (d) 10.79 (e) 11.52

27&28. What is the enthalpy change of the reaction below at 298 K and 1 atm pressure?

\[
\Delta H_f^{298} \text{ (kJ/mol)} = -205.6 \quad \text{0} \quad -348.3 \quad -296.8
\]

(a) \(-879.0 \text{ kJ}\) (b) \(-270.6 \text{ kJ}\) (c) \(-762.1 \text{ kJ}\)
(d) \(-651.0 \text{ kJ}\) (e) \(+1524.1 \text{ kJ}\)
29&30. A 0.50 M solution of a monoprotic acid is 0.24% ionized. What is the $K_a$ for this weak acid?

(a) $1.3 \times 10^{-3}$  (b) $3.7 \times 10^{-4}$  (c) $1.2 \times 10^{-6}$  (d) $1.8 \times 10^{-7}$  (e) $2.9 \times 10^{-6}$

31&32. Rate data were collected for the following reaction at a particular temperature. What is the correct rate law expression?

$$2X + Y \rightarrow Z$$

<table>
<thead>
<tr>
<th>Experiment</th>
<th>$[X]_{initial}$</th>
<th>$[Y]_{initial}$</th>
<th>Initial Rate of Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.60 M</td>
<td>0.20 M</td>
<td>0.050 M/s</td>
</tr>
<tr>
<td>2</td>
<td>0.30 M</td>
<td>0.20 M</td>
<td>0.025 M/s</td>
</tr>
<tr>
<td>3</td>
<td>0.60 M</td>
<td>0.40 M</td>
<td>0.20 M/s</td>
</tr>
</tbody>
</table>

(a) Rate = $k[X][Y]$  (b) Rate = $kX^2[Y]$  (c) Rate = $k[X][Y]^2$
(d) Rate = $k[X]^2[Y]^2$  (e) Rate = $k[X]^2$
33&34. Estimate the temperature at which the following reaction is at equilibrium:

\[
\text{NH}_3(g) + \text{HCl}(g) \rightarrow \text{NH}_4\text{Cl}(s)
\]

when

\[\Delta H_{\text{reaction}} = -176 \text{ kJ}\]
\[\Delta S_{\text{reaction}} = -284.5 \text{ J/K}\]

(a) 619 K (b) 680 K (c) 634 K (d) 582 K (e) 467 K

35&36. Consider the equilibrium at a certain temperature: \[Z \rightleftharpoons X + 3Y\]

A reaction begins with 6.0 moles of Z in a 3.0 L container. When the system reaches equilibrium, there are 3.0 moles of X present. What is the value of the equilibrium constant, \(K_c\)?

(a) 0.037 (b) 6 (c) 0.11 (d) 27 (e) 0.081
37\&38. What concentration of Pb\(^{2+}\) will initiate precipitation in a solution that is 0.010 M NaBr?

(a) 6.3 \times 10^{-1} M  
(b) 6.3 \times 10^{-4} M  
(c) 6.3 \times 10^{-2} M  
(d) 6.3 \times 10^{-6} M  
(e) 6.3 \times 10^{-5} M  

39\&40. Calculate the pH after 15.0 mL of 0.200 M NaOH has been added to a 50.0 mL sample of 0.100 M nitrous acid.

(a) 2.92  
(b) 3.00  
(c) 3.13  
(d) 3.52  
(e) 3.66
41&42. What is the pH of a solution that is 0.50 M CH₃NH₃Cl?

(a) 8.12  (b) 5.50  (c) 9.46  (d) 4.32  (e) 7.00

43&44. Consider the following equilibrium reaction:

\[ \text{Br}_2(g) + \text{F}_2(g) \rightleftharpoons 2\text{BrF}(g) \]

\[ K_c = 54.7 \text{ at a specified temperature} \]

If the initial concentration of BrF in a closed container is 1.00 M, what will be the concentration of BrF after the system finally reaches equilibrium?

(a) 0.661 M  (b) 0.500 M  (c) 0.287 M  (d) 0.147 M  (e) 0.788 M
45&46. How many grams of Al will be deposited from molten AlCl₃ by a current of 15.0 amperes flowing for 24.0 minutes if the electrode efficiency is only 65.0%?

(a) 1.31 g  (b) 2.42 g  (c) 1.75 g  (d) 5.40 g  (e) 11.6 g

47&48. Calculate the concentration of Sn⁴⁺ in a saturated solution of Sn(OH)₄.

(a) 3.3 x 10⁻¹¹ M  (b) 1.3 x 10⁻¹² M  (c) 4.5 x 10⁻²⁰ M
(d) 6.2 x 10⁻¹⁵ M  (e) 4.8 x 10⁻¹⁸ M
49&50. Which answer best represents the species present for the equilibrium $2A \rightleftharpoons B$ when $K_c = 1000$, where

- $\bigcirc = A$
- $\bullet = B$

(a) ![Diagram](a.png)
(b) ![Diagram](b.png)
(c) ![Diagram](c.png)
(d) ![Diagram](d.png)
(e) ![Diagram](e.png)

51. Take the on-line questionnaire on our course (5 pts) - see your neo account.
PART 2

Please read and sign: “On my honor, as an Aggie, I have neither given nor received unauthorized aid on this exam.” ______________________________________________________________________

(5 pts) 52. (a) Name this compound: (include cis or trans)

(b) Define what an isomer is.

(6 pts) (c) Draw and name a CYCLIC isomer of the compound given in (a).
53. Roughly sketch two graphs with pH on the y axis and volume of titrant added on the x axis for:

(a) The titration of nitrous acid with sodium hydroxide
(b) The titration of nitric acid with sodium hydroxide.

Note where pH = 7 on each graph.
(7 pts) 54. (a) Draw the voltaic cell that results when the following two half-cells are connected:
   (1) a lead electrode is inserted into a solution of 0.0010 M Pb^{2+} ions.
   (2) a silver electrode is inserted into a solution of 0.010 M Ag^{+} ions.

   Which is the anode and what is the anodic reaction?
   Which is the cathode and what is the cathodic reaction?
   What is the sign on each electrode?
   Show the direction of the electron flow.
   What is the overall reaction?

(3 pts)  (b) Write the shorthand notation for this cell.

(5 pts)  (c) Calculate the equilibrium constant for the overall reaction.

(5 pts)  (d) Calculate the potential for this non-standard cell.
SCRAP PAPER OR COMMENTS ON THIS EXAM