1&2. An electron has a mass number of ________, a charge of ________, and a mass equal to that of a(an) ____________.

(a) 0, -1, proton  
(b) 1, 0, neutron  
(c) 0, -1, positron  
(d) 0, -1, alpha particle  
(e) 0, 0, proton

3&4. Which is the correct $K_c$ expression for the equilibrium: $\text{Cr(s)} + 3\text{Cu}^+(\text{aq}) \rightleftharpoons 3\text{Cu(s)} + \text{Cr}^{3+}(\text{aq})$?

(a) $K_c = \frac{[\text{Cr}^{3+}]}{[\text{Cu}^+]^3}$  
(b) $K_c = \frac{3[\text{Cu}^+]^3}{[\text{Cr}^{3+}]}$  
(c) $K_c = \frac{[\text{Cr}][\text{Cu}^+]^3}{[\text{Cu}]^3[\text{Cr}^{3+}]}$

(d) $K_c = \frac{[\text{Cu}][\text{Cr}^{3+}]}{[\text{Cr}][\text{Cu}^+]^3}$  
(e) $K_c = \frac{[\text{Cr}^{3+}]}{3[\text{Cu}^+]}$

5&6. Complete and balance the following equation. The missing term is ____________.

$^{235}\text{U} + ^1\text{n} \rightarrow _____ + ^{94}\text{Kr} + 3^1\text{n}$

(a) $^{142}\text{Ba}$  
(b) $^{139}\text{Ba}$  
(c) $^{139}\text{Ce}$  
(d) $^{139}\text{Xe}$  
(e) $^{142}\text{I}$
7&8. Which statement is correct at constant pressure and temperature?

(a) $\Delta H^\circ$ for Ne(l) is zero at 298 K, by definition.
(b) At constant pressure, $\Delta H = \Delta E - P\Delta V$
(c) For a spontaneous process such as gaseous diffusion, $\Delta S < 0$.
(d) If $\Delta H$ for reaction A is greater than $\Delta H$ for reaction B, then reaction A will proceed more rapidly than reaction B.
(e) $\Delta G = \Delta H - T\Delta S$

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

![Chemical Structure]

(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. Which of the following salts has the highest molar solubility?

(a) BaF\textsubscript{2}  (b) CaF\textsubscript{2}  (c) MgF\textsubscript{2}  (d) SnS\textsubscript{2}  (e) PbI\textsubscript{2}

17&18. For the standard voltaic cell using Fe^{2+}/Fe and Au^{3+}/Au electrode compartments, which of the following statements is FALSE?

(a) The initial concentration of Fe^{2+} ions in the half cell must be 1.0 M.
(b) The standard cell potential is 1.94 V.
(c) The gold electrode is labeled “-”.
(d) The electron flow through the external wire is from the iron electrode to the gold electrode.
(e) The iron electrode is the anode.

19&20. Consider the following gas phase reaction: A + 2B → AB\textsubscript{2}
occurs by the following mechanism:

\begin{align*}
\text{Step 1} & \quad A + B \rightarrow AB \quad \text{slow} \\
\text{Step 2} & \quad AB + B \rightarrow AB_2 \quad \text{fast} \\
\text{Overall} & \quad A + 2B \rightarrow AB_2
\end{align*}

The rate law expression must be Rate = \underline{\phantom{00000000}}.

(a) k[A]  (b) k[B]  (c) k[A][B]^2  (d) k[B]^2  (e) k[A][B]
221&22. Which of the following solutions will have the highest pH? (Calculations are not necessary.)

(a) 0.10 M hydrochloric acid
(b) 0.10 M acetic acid
(c) 0.10 M hydrofluoric acid
(d) 0.10 M hypochlorous acid
(e) 0.10 M formic acid

23&24. If the activation energy in the forward direction of a single step reaction, \( A \rightarrow B \), is 68 kJ and the activation energy in the reverse direction is 75 kJ, what is the energy of reaction \( \Delta E \) for this reaction? (Hint: draw the activation energy diagram.)

(a) +143 kJ  (b) -7 kJ  (c) +7 kJ  (d) -143 kJ  (e) + 71 kJ
25 & 26. What is the pH of a 0.020 \textit{M} hypobromous acid solution (\(K_a = 2.5 \times 10^{-9}\))?

(a) 5.70 \hspace{1cm} (b) 7.00 \hspace{1cm} (c) 4.22 \hspace{1cm} (d) 5.15 \hspace{1cm} (e) 6.63

27 & 28. Calculate the standard enthalpy change for the reaction below.

\[
\text{C(graphite)} + 4 \text{HNO}_3(\text{l}) \rightarrow \text{CO}_2(\text{g}) + 4 \text{NO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{l})
\]

when \(\Delta H^\circ_{\text{f}}\) of \text{HNO}_3(\text{l}) = -174.1 \text{ kJ/mol}

\(\Delta H^\circ_{\text{f}}\) of \text{CO}_2(\text{g}) = -393.5 \text{ kJ/mol}

\(\Delta H^\circ_{\text{f}}\) of \text{NO}_2(\text{g}) = +33.2 \text{ kJ/mol}

\(\Delta H^\circ_{\text{f}}\) of \text{H}_2\text{O}(\text{l}) = -285.8 \text{ kJ/mol}

(a) -123.9 \text{ kJ} \hspace{1cm} (b) -472.1 \text{ kJ} \hspace{1cm} (c) -201.9 \text{ kJ}

(d) -404.8 \text{ kJ} \hspace{1cm} (e) -135.9 \text{ kJ}
29&30. The actual mass of an atom of $^{52}$Cr is 51.94059 amu. Calculate its mass deficiency.
   (a) 0.422 amu/atom  (b) 0.491 amu/atom  (c) 0.711 amu/atom
   (d) 0.621 amu/atom  (e) 0.513 amu/atom

31&32. Kinetic studies were done on the reaction:
   \[ A + 2B \rightarrow C \]
   and the following data were obtained:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>$[A]_{\text{initial}}$</th>
<th>$[B]_{\text{initial}}$</th>
<th>Rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$2.0 \times 10^{-3}$ M</td>
<td>$4.0 \times 10^{-3}$ M</td>
<td>$5.7 \times 10^{-7}$</td>
</tr>
<tr>
<td>2</td>
<td>$4.0 \times 10^{-3}$ M</td>
<td>$4.0 \times 10^{-3}$ M</td>
<td>$22.8 \times 10^{-7}$</td>
</tr>
<tr>
<td>3</td>
<td>$2.0 \times 10^{-3}$ M</td>
<td>$8.0 \times 10^{-3}$ M</td>
<td>$11.4 \times 10^{-7}$</td>
</tr>
</tbody>
</table>

Determine the rate law for this reaction.
   (a) rate = $k[A][B]$  (b) rate = $k[A] / [B]$  (c) rate = $k[A][B]^2$
   (d) rate = $k[A]^2[B]$  (e) none of the above
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. 1.0 mol of ICl is placed in a 1.0 L flask, and the flask is heated. What are the concentrations of chlorine and iodine at equilibrium if \( K_c \) for the reaction below is \( 1.0 \times 10^{-2} \)?

\[ 2 \text{ICl}(g) \rightarrow \text{I}_2(g) + \text{Cl}_2(g) \]

(a) 0.094 mol/L (b) 0.50 mol/L (c) 0.083 mol/L
(d) \( 1.00 \times 10^{-5} \) mol/L (e) 2.50 mol/L
37&38. What is the pH of a buffer solution that is 0.30 M HF and 0.20 M NaF?

(a) 3.55  (b) 3.16  (c) 2.01  (d) 2.97  (e) 2.45

39&40. In class, we discussed the radioactive isotope, polonium-210. Polonium has many other isotopes including polonium-198 which decays with a half-life of 1.7 minutes to lead-194:

$$^{198}_{84}\text{Po} \rightarrow ^{4}_{2}\alpha + ^{194}_{82}\text{Pb}$$

Consider a 25.0 g sample of polonium-198. How many grams would remain in the sample after 10.0 minutes?

(a) 0.42 g  (b) 0.0039 g  (c) 0.29 g  (d) 0.57 g  (e) 1.55 g
41&42. What is the pH of a 0.50 M NaF solution?

- (a) 2.81
- (b) 7.00
- (c) 8.42
- (d) 8.66
- (e) 9.51

43&44. 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^{-2} M
- (c) 6.3 \times 10^{-6} M
- (d) 6.3 \times 10^{-2} M
- (e) 6.3 \times 10^{-5} 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) $3.3 \times 10^{-11}$ M  (b) $1.3 \times 10^{-12}$ M  (c) $4.5 \times 10^{-20}$ M
(d) $6.2 \times 10^{-15}$ M  (e) $4.8 \times 10^{-18}$ M
49&50. Which answer best represents the species present for the equilibrium $2A \rightleftharpoons B$ when $K_c = 1000$, where

- $\circ = A$ and $\bullet = B$?

(a) ![Diagram](image1)  
(b) ![Diagram](image2)  
(c) ![Diagram](image3)  
(d) ![Diagram](image4)  
(e) ![Diagram](image5)

51. Take the on-line questionnaire on our course (5 pts) - see our webpage.
(6 pts) **52.** Draw and name 3 different structural isomers of C\textsubscript{7}H\textsubscript{16}.

(5 pts) **53.** Calculate the potential (in volts) for the voltaic cell at 25°C given below:

\[ \text{Cu/Cu}^{2+}(0.00010 \text{ M}) \parallel \text{Au}^{3+}(0.10 \text{ M})/\text{Au} \]
54. Draw the structure for 3,4-dimethyl-cis-2-pentene.

55. (a) Write the equilibrium reaction for the ionization of ammonia in aqueous solution.
(b) What is the pH of a 0.40 M ammonia solution?

56. 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.
(10 pts) 57. (a) Draw the electrolytic cell that results when aqueous NaBr is electrolyzed. The observations are:

(1) solution turns brown around one electrode as bromine liquid dissolves, and
(2) gaseous hydrogen bubbles from the other electrode and the solution near the electrode becomes more basic.

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?
SCRAP PAPER OR COMMENTS ON THIS EXAM