IMPORTANT: On the scantron (answer sheet), you MUST clearly fill your name, your student number, section number, and test form (white cover = test form A; yellow cover = test form B). Use a #2 pencil.

There are 25 questions on this exam. Check that you have done all of the problems and filled in the first 25 bubbles on the scantron. The maximum score on this exam is 25 points. Your score will be reported in percent (max 100%).

Exam policy

- Calculators with text-programmable memory are not allowed.
- Relevant data and formulas, including the periodic table, are attached at the end of this exam.
- Your grade will be based only on what is on the scantron form.
- The answer key will be posted on the web after the exam (on the Exam Schedule page).
- You must turn in your cover sheet with your scantron answer form.
- You MUST bubble in all of your answers before the time is up; you may not bubble your scantron after the time is called.

Hints

- As you read the question, underline or circle key words to highlight them for yourself. Avoid errors from "mis-reading" the question.
- Pay attention to units and magnitudes (decimal places) of numbers obtained from calculations.
- There is no penalty for guessing.
Chem 112 EXAM 3
PRACTICE EXAM 3A

1) A voltaic cell is constructed from Nittnium and Aluminum:

\[
\text{Al (s)} \mid \text{Al(NO}_3\text{)}_3 (0.3 \text{ M, aq}) \parallel \text{Nt(NO}_3\text{)}_2 (5.0 \times 10^{-5} \text{ M, aq}) \mid \text{Nt (s)}
\]

If \( E^\circ_{\text{cell}} \) is 3.14V, what is \( E_{\text{cell}} \) at 25°C under the written conditions?

A. 1.87 V
B. 2.32 V
C. 4.40 V
D. 3.95 V
E. 3.02 V

2) Hydrogen peroxide (H\(_2\)O\(_2\)) makes excellent elephant’s toothpaste, a mean witch’s brew, and an enthusiastically boiling solution with the help of a catalyst. What is the oxidation state of oxygen in hydrogen peroxide?

A) \(-4\)
B) \(-\frac{1}{2}\)
C) \(-2\)
D) \(-1\)
E) \(+2\)

3) Which of the following would offer cathodic protection to Fe(s) in order to prevent rust at 25°C?

A) Ag (s)
B) NO (g)
C) Sn (s)
D) Zn (s)
E) Al\(^{3+}\) (aq)
4) The hard-working graduate students at PSU are delighted to find that newly discovered *Nittnium* actually can be readily incorporated into a galvanic cell. To harness its power, the students create a *Lithium-Nittnium battery*, which undergoes the following process:

\[
\text{Li (s) + Nt}^{+} (aq) \rightarrow \text{Li}^{+} (aq) + \text{Nt (s)} \quad K_{eq} = 1.224 \times 10^{69}
\]

What is the $E^{\circ}_{1/2}$ (red) of the Nittnium ion at 25°C?

A) + 6.34 V  
B) + 4.09 V  
C) + 1.04 V  
D) + 0.42 V  
E) − 0.42 V

5) What is one of the differences between a voltaic cell and an electrolytic cell?

A) In an electrolytic cell an electric current is produced by a chemical reaction.  
B) In an electrolytic cell electrons flow towards the anode.  
C) In an electrolytic cell a non-spontaneous reaction is forced to occur.  
D) In an electrolytic cell O₂ gas is always produced at the cathode.  
E) In an electrolytic cell only non-aqueous electrolyte solutions can be used.

6) What is the maximum amount of work that can performed by the following voltaic cell under standard conditions at 25°C?

\[
\text{Cd (s) + Pt}^{2+} (aq) \rightarrow \text{Cd}^{2+} (aq) + \text{Pt (s)}
\]

A) 2 kJ/mol  
B) 102 kJ/mol  
C) 155 kJ/mol  
D) 77 kJ/mol  
E) 309 kJ/mol
7) After spending a few hours in the cellular signal void known as East Halls, Frank is dismayed to notice that the lithium ion battery in his phone is completely discharged. If his cell phone charger uses 2.7 Amperes of electricity, how long will it take to completely recharge the 2.8 g of Li in his battery by reducing it according to the reaction below at 25°C?

\[
\text{Li}^+ + e^- \rightarrow \text{Li (s)}
\]

A) 3.0 hours  
B) 4.0 hours  
C) 6.0 hours  
D) 6.5 hours  
E) 5,250,600 minutes

8) What is the missing product in this fission reaction?

\[
^{235}\text{U} + ^1\text{n} \rightarrow 3 ^1\text{n} + ^{90}\text{Sr} + ___
\]

A) \(^{142}\text{I}\)  
B) \(^{143}\text{I}\)  
C) \(^{146}\text{I}\)  
D) \(^{142}\text{Xe}\)  
E) \(^{143}\text{Xe}\)

9) Which of the following salts would become more soluble under aqueous acidic conditions at 25°C?

i) AgCl (s)  
ii) Ag\(_2\)S (s)  
iii) PbF\(_2\) (s)  
iv) Cu(OH)\(_2\) (s)

A) i and iv only  
B) i, ii, and iv only  
C) ii and iv only  
D) ii, iii, and iv only  
E) All of the above
10) Which one of the following statements is true?

A) Beta decay results in the conversion of a proton into a neutron.
B) Positron emission increases the nuclear charge of an atom.
C) Nuclear decay always follows second-order kinetics.
D) Gamma decay produces high-energy radiation.
E) Alpha decay decreases the atomic number of the parent atom by 1.

11) What reaction is taking place at the anode?

A) Ni (s) → Ni^{2+} (aq) + 2e^−
B) Zn (s) → Zn^{2+} (aq) + 2e^−
C) Ni^{2+} (aq) + 2e^− → Ni (s)
D) Zn^{2+} (aq) + 2e^− → Zn (s)
E) Ni^{2+} + 2NO_3^- (aq) → Ni(NO_3)_2 (s)

12) What is the $E^{\circ}_{cell}$ of the galvanic cell pictured above at 25°C?

A) 0.483 V
B) 0.442 V
C) 0.524 V
D) 0.401 V
E) 0.561 V
13) Which of the following would increase the $E_{\text{cell}}$ of the galvanic cell pictured above?

i. Increase the concentration of $\text{Zn}^{2+} (aq)$
ii. Increase the concentration of $\text{Ni}^{2+} (aq)$
iii. Increase the mass of the solid nickel strip
iv. Increase the mass of the solid zinc strip

A) i only  
B) ii only  
C) i and iv only  
D) ii and iii only  
E) All of the above

14) Which of the following are true in an electrochemical reaction *spontaneously* proceeding in the forward direction as written?

i) $E_{\text{cell}} < 0$
ii) $\Delta G_{\text{run}} < 0$
iii) $Q < K_{\text{eq}}$
iv) Electrons will flow from the cathode toward the anode

A) ii only  
B) i and ii only  
C) ii and iii only  
D) i, ii, and iv only  
E) ii, iii, and iv only

15) What is the molar solubility of $\text{Cd(OH)}_2$ when the solution is buffered at pH = 9 at 25°C? ($K_{sp}$ of $\text{Cd(OH)}_2 = 2.0 \times 10^{-14}$)

A) $2.0 \times 10^{-4}$ M  
B) $2.0 \times 10^{-9}$ M  
C) $1.4 \times 10^{-2}$ M  
D) $1.4 \times 10^{-7}$ M  
E) $1.0 \times 10^{-5}$ M
16) What is the nuclear binding energy of a Lithium-7 nucleus in kJ/mol? (The atomic mass of one Lithium-7 nucleus is 7.016003 amu.)

A) $7.023 \times 10^3$ kJ/mol  
B) $9.126 \times 10^5$ kJ/mol  
C) $5.226 \times 10^6$ kJ/mol  
D) $3.644 \times 10^9$ kJ/mol  
E) $7.424 \times 10^{17}$ kJ/mol

17) Which one of the following species is the strongest oxidizing agent at 25°C?

$\text{Na}^+$ (aq), $\text{Br}_2$ (ℓ), $\text{Fe}^{2+}$ (aq), $\text{F}^-$ (aq), $\text{Ni}^{2+}$ (aq)

A) $\text{Na}^+$ (aq)  
B) $\text{Br}_2$ (ℓ)  
C) $\text{Fe}^{2+}$ (aq)  
D) $\text{F}^-$ (aq)  
E) $\text{Ni}^{2+}$ (aq)

18) Which of the following isotopes are most likely to undergo beta decay?

A) $^1\text{H}$  
B) $^{12}\text{N}$  
C) $^{14}\text{C}$  
D) $^{19}\text{Ne}$  
E) $^{235}\text{U}$

19) A group of ambitious Penn State graduate students synthesize a new element and decide to call it Nittnium. Further experimentation determines the half-life of Nittnium to be 1,855 s. The students create a batch of Nittnium to run experiments on, but then they let it sit for one hour while they run to West Halls to grab some cookies. What fraction of Nittnium will remain when they get back to their lab?

A) 3%  
B) 14%  
C) 26%  
D) 34%  
E) 48%
20) What is the final product when Uranium-238 undergoes 5 alpha decay reactions and 2 beta decay reactions?

A) radon-226
B) lead-218
C) polonium-218
D) plutonium-244
E) radium-226

21) What is the concentration of I⁻ ions in an aqueous saturated solution of CuI₂ at 25°C?
(K_{sp} of CuI₂ = 1.1 \times 10^{-12})

A) 5.2 \times 10^{-7} M
B) 1.0 \times 10^{-6} M
C) 6.5 \times 10^{-5} M
D) 1.3 \times 10^{-4} M
E) 2.1 \times 10^{-6} M

22) A wooden artifact discovered in the Sahara desert by Rick T. Cat is sent to the lab to be carbon dated. It possesses a \(^{14}\text{C}\) activity of 10.2 disintegrations per second. Given that the half-life of \(^{14}\text{C}\) is 5,715 years and the activity of an equal mass of freshly cut wood has a constant value of 15.2 disintegrations per second, how old is the artifact?

A. 1.9 \times 10^6 years
B. 1,234 years
C. 10,928 years
D. 4,230 years
E. 3,290 years

23) If an electrical current is run through an electrolytic cell that contains aqueous 1 M AlBr₃ (aq), what will be the initial product formed at the cathode at 25°C?

A) H₂ (g)
B) Al (s)
C) Al(OH)₃(s)
D) O₂ (g)
E) Br₂ (ℓ)
24) A table of solubility products is provided below. If 0.05 M AgNO₃ (aq) is added dropwise to an aqueous solution that contains a mixture of 1 M NaI, 1 M KCl, and 1 M KIO₃, what will be the first solid to precipitate out at 25°C?

<table>
<thead>
<tr>
<th>Salt</th>
<th>K&lt;sub&gt;sp&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>AgI</td>
<td>8.5 x 10⁻¹⁷</td>
</tr>
<tr>
<td>AgCl</td>
<td>1.8 x 10⁻¹⁰</td>
</tr>
<tr>
<td>AgIO₃</td>
<td>3.0 x 10⁻⁸</td>
</tr>
</tbody>
</table>

A)  AgI (s)  
B)  KI (s)  
C)  AgCl (s)  
D)  AgIO₃ (s)  
E)  Ag (s)

25) When the following unbalanced redox reaction is balanced in a basic solution, what is the coefficient in front of the H₂O(ℓ), and is it a reactant or a product?

\[ \text{MnO}_4^- (aq) + \text{NO} (g) \rightarrow \text{MnO}_2 (s) + \text{NO}_2 (g) \]

A)  1, reactant  
B)  2, product  
C)  1, product  
D)  2, reactant  
E)  4, product

-------------------------------------------------------------------------------------------------------------------------------------

END OF TEST

-------------------------------------------------------------------------------------------------------------------------------------
ANSWER KEY:

1. E
2. D
3. D
4. C
5. C
6. E
7. B
8. E
9. D
10. D
11. B
12. A
13. B
14. C
15. A
16. D
17. B
18. C
19. C
20. C
21. D
22. E
23. A
24. A
25. A