KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS
CHEMISTRY DEPARTMENT
CHEM 102 FINAL EXAM
TERM 122

TEST CODE NUMBER   005

STUDENT NUMBER: _____________________________
NAME : _____________________________________
SECTION NUMBER: _____________________________

INSTRUCTIONS
1. Write your student number, name, and section number on the EXAM COVER page.
2. Write your student number, section number, and your name on your EXAM ANSWER FORM.
3. Bubble in pencil your student number and your section number on the EXAM ANSWER FORM.
4. Bubble in pencil on your EXAM ANSWER FORM the correct answer to each of the questions. You must not give more than ONE answer per question.
5. At the end of the exam return the EXAM ANSWER FORM to the proctor.
6. The exam contains 40 multiple choice questions and the time allowed is 160 min.

PLEASE TURN OFF YOUR CELL PHONE AND PLACE IT UNDER YOUR SEAT

Important constants

<table>
<thead>
<tr>
<th>Constant</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Constant (R)</td>
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<td>L.atm/(mol.K)</td>
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<tr>
<td></td>
<td>8.314</td>
<td>J/(mol.K)</td>
</tr>
<tr>
<td></td>
<td>8.31 x 10^7</td>
<td>g.cm^2/(sec^2.mol.K)</td>
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<tr>
<td>Planck’s Constant (h)</td>
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<td>J.sec/particle</td>
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<td></td>
<td>6.626 x 10^{-34}</td>
<td>kg.m^2/(sec.particle)</td>
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<tr>
<td>Speed of light (c)</td>
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<td>m/sec</td>
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<td>Avogadro’s number (N)</td>
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<td>particles/mole</td>
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<td>Bohr’s Constant (R_H)</td>
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<td>Faraday (F)</td>
<td>96500</td>
<td>Coulombs/mol.e^-</td>
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<tr>
<td>Specific heat of H_2O</td>
<td>4.184</td>
<td>J/(g.°C)</td>
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1. For a reaction that follows the general rate law, $\text{Rate} = k[A][B]^2$, suppose the rate of the reaction at certain initial concentrations of A and B is 0.0115 M/s. What is the rate of this reaction if concentrations of both A and B are doubled?

A) 0.023 M/s  
B) 0.046 M/s  
C) 0.092 M/s  
D) 0.184 M/s

2. A certain reaction, $\text{A} \rightarrow \text{products}$, has a rate that slows down as the reaction proceeds. The half-life of the reaction is found to depend on the initial concentration of A. Which of the following statement is true about this reaction?

A) A doubling of the concentration of A doubles the rate of the reaction.  
B) A plot of $1/[A]$ versus time is linear.  
C) The half-life of the reaction gets longer when the initial concentration of A is increased.  
D) A plot of the concentration of A versus time has a constant slope.

3. Hydrogen iodide decomposes at 800 K via a second-order process to produce hydrogen and iodine according to the following chemical equation:

$$2 \text{HI}(g) \rightarrow \text{H}_2(g) + \text{I}_2(g)$$

At 800 K, it takes 142 seconds for the initial concentration of HI to decrease from $6.75 \times 10^{-2}$ M to $3.50 \times 10^{-2}$ M. What is the rate constant for the reaction at this temperature?

A) 10.3 M$^{-1}$s$^{-1}$  
B) $5.12 \times 10^{-4}$ M$^{-1}$s$^{-1}$  
C) $1.95 \times 10^{3}$ M$^{-1}$s$^{-1}$  
D) $9.69 \times 10^{-2}$ M$^{-1}$s$^{-1}$
4. Each of the following diagrams (I, II, III, IV) describes a possible reaction:

\[ \text{A}_2(g) + \text{B}_2(g) \rightleftharpoons 2 \text{AB}(g) \]

Assume that you begin with equal amounts of A\(_2\) and B\(_2\), but no AB, and assuming that ΔS is the same for all of the possible reactions, which of these diagrams would represent that the amount of AB\((g)\) at equilibrium is the greatest?

A) I  
B) II  
C) III  
D) IV

5. When 2.00 mol each of H\(_2\)(g) and Cl\(_2\)(g) are reacted in a 1.00 L container at a certain temperature, 3.50 mol of HCl is present at equilibrium.

\[ \text{H}_2(g) + \text{Cl}_2(g) \rightleftharpoons 2 \text{HCl}(g) \]

Calculate the value of the equilibrium constant, \(K_c\).

A) 196  
B) 140  
C) 56.0  
D) 33.0

6. For the following reaction:

\[ \text{CO}(g) + \text{Cl}_2(g) \rightarrow \text{COCl}(g) + \text{Cl}(g) \quad K_{eq} = 1.5 \times 10^{-39} \]

If the rate constant, \(k\), for the forward reaction is \(1.4 \times 10^{-28} \text{ L.mol}^{-1}.\text{sec}^{-1}\), what is \(k\) (in \(\text{L. mol}^{-1}.\text{sec}^{-1}\)) for the backward reaction?

A) \(9.3 \times 10^{10}\)  
B) \(1.0 \times 10^{-11}\)  
C) \(2.1 \times 10^{67}\)  
D) \(7.1 \times 10^{27}\)
7. Consider these reactions and their corresponding equilibrium constants.

\[
\begin{align*}
\frac{1}{2} \text{N}_2 & + \text{O}_2 \rightleftharpoons \text{NO}_2 & K_1 \\
2 \text{NO}_2 & \rightleftharpoons 2 \text{NO} + \text{O}_2 & K_2 \\
\text{NOBr} & \rightleftharpoons \text{NO} + \frac{1}{2} \text{Br}_2 & K_3
\end{align*}
\]

Express the \( K \) value for the reaction below in terms of \( K_1, K_2, \) and \( K_3 \).

\[
\frac{1}{2} \text{N}_2 + \frac{1}{2} \text{O}_2 + \frac{1}{2} \text{Br}_2 \rightleftharpoons \text{NOBr} \quad K = ?
\]

A) \( \frac{K_1 K_2^{1/2}}{K_3} \)  
B) \( K_1 + K_2^{1/2} - K_3 \)  
C) \( \frac{K_1 K_2}{2 K_3} \)  
D) \( K_1 + \frac{K_2}{2} - K_3 \)

8. Consider the equilibrium

\[
2 \text{NOBr(g)} \rightleftharpoons 2 \text{NO(g)} + \text{Br}_2(g)
\]

If nitrosyl bromide (NOBr) is 34 percent dissociated at 25°C and the total pressure is 0.25 atm, calculate \( K_p \) for the dissociation at this temperature.

A) \( 9.6 \times 10^{-3} \)  
B) \( 3.9 \times 10^{-4} \)  
C) \( 4.5 \times 10^{-2} \)  
D) \( 5.0 \times 10^{-2} \)

9. Of the following carboxylic acids, which is the most acidic?

A) \( \text{Cl}_3\text{CCO}_2\text{H} \)  
B) \( \text{HCO}_2\text{H} \)  
C) \( \text{CH}_3\text{CO}_2\text{H} \)  
D) \( \text{(CH}_3)_3\text{CCO}_2\text{H} \)

10. Calculate the \([\text{H}^+])\) in a 0.25 \( M \) solution of methylamine, \( \text{CH}_3\text{NH}_2 \) (\( K_b = 4.4 \times 10^{-4} \)).

A) \( 1.0 \times 10^{-2} \)  
B) \( 9.5 \times 10^{-13} \)  
C) \( 9.1 \times 10^{-11} \)  
D) \( 1.1 \times 10^{-4} \)
11. Which salt produces the most alkaline solution at a concentration of 0.1 M?

A) MgCl$_2$
B) NH$_4$I
C) KClO$_4$
D) NaNO$_2$

12. Calculate the concentration of H$^+$, in a 0.25 M H$_2$C$_2$O$_4$ solution. $K_{a1}$ and $K_{a2}$ for oxalic acid (H$_2$C$_2$O$_4$) are 6.5×10$^{-2}$ and 6.1×10$^{-5}$, respectively.

A) 3.3×10$^{-5}$ M
B) 0.099 M
C) 0.13 M
D) 6.1×10$^{-5}$ M

13. 1.0 L of an aqueous solution in which [H$_2$CO$_3$] = [HCO$_3^-$] = 0.10 M, has [H$^+$] = 4.2×10$^{-7}$. What is the [H$^+$] after 0.005 mole of NaOH has been added?

A) 2.2×10$^{-8}$ M
B) 2.1×10$^{-9}$ M
C) 3.8×10$^{-7}$ M
D) 4.6×10$^{-7}$ M

14. The solubility product ($K_{sp}$) for Fe(OH)$_2$ and Fe(OH)$_3$ are 8.0×10$^{-15}$ and 6.0×10$^{-38}$, respectively. What are the concentrations of Fe$^{2+}$ and Fe$^{3+}$ at pH 8?

A) 8.0×10$^{-3}$ and 6.0×10$^{-20}$
B) 8.0×10$^{-3}$ and 1.2×10$^{-2}$
C) 4.0×10$^{-7}$ and 6.0×10$^{-14}$
D) 1.3×10$^{-5}$ and 2.2×10$^{-10}$

15. A solution of Pb(NO$_3$)$_2$ is added dropwise to a second solution in which [Cl$^-$] = [F$^-$] = [I$^-$] = [SO$_4^{2-}$] = 0.001 M. What is the first precipitate that forms?

A) PbSO$_4$ ($K_{sp}$ = 1.8×10$^{-8}$)
B) PbF$_2$ ($K_{sp}$ = 3.7×10$^{-8}$)
C) PbI$_2$ ($K_{sp}$ = 8.5×10$^{-9}$)
D) PbCl$_2$ ($K_{sp}$ = 1.5×10$^{-5}$)
16. For a certain process the entropy change, $\Delta S$, is $+148.3$ J/molK and the free energy change, $\Delta G$, is $+146$ kJ/mol at $35^\circ$C. Find $\Delta H$ at $35^\circ$C.

A) 192 kJ/mol  
B) 151 kJ/mol  
C) 141 kJ/mol  
D) 100. kJ/mol

17. Consider the reaction

$$2 \text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2 \text{SO}_3(g)$$

carried out at $25^\circ$C and 1 atm. Calculate the equilibrium constant for this reaction at $25^\circ$C, using the following data:

<table>
<thead>
<tr>
<th>Substance</th>
<th>$\Delta H^\circ$ (kJ/mol)</th>
<th>$S^\circ$ (J/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{SO}_2(g)$</td>
<td>-297</td>
<td>248</td>
</tr>
<tr>
<td>$\text{SO}_3(g)$</td>
<td>-396</td>
<td>257</td>
</tr>
<tr>
<td>$\text{O}_2(g)$</td>
<td>0</td>
<td>205</td>
</tr>
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</table>

A) $K = 2.06 \times 10^{57}$  
B) $K = 1.98$  
C) $K = 8.69 \times 10^{24}$  
D) $K = 332$

18. The following diagrams show a spontaneous chemical reaction. What can you deduce about $\Delta S_{\text{surr}}$ for this process?

A) $\Delta S_{\text{surr}}$ is negative  
B) $\Delta S_{\text{surr}}$ is positive  
C) $\Delta S_{\text{surr}}$ is zero  
D) This diagram alone is not enough to deduce the sign of $\Delta S_{\text{surr}}$.  

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Page 6
19. Which of the following is true about carbon monoxide?

   A) single largest source is from internal combustion engine
   B) results from the actions of ultraviolet light on ozone
   C) is a secondary pollutant
   D) major cause of cancer in smokers

20. Of the following materials, which contributes most to the production of acid rain?

   A) Nitric oxide
   B) Uranium hexafluoride
   C) Phosphate detergents
   D) Chlorofluorocarbons

21. Which of the following is a possible consequence of increasing carbon dioxide in the atmosphere?

   A) An increase in chlorofluorocarbons in the atmosphere.
   B) An increase in ultraviolet radiation reaching the Earth's surface.
   C) A rise in sea level.
   D) depletion of ozone layer.

22. What is the oxidation number of vanadium, V, in the complex compound K₃[V(EDTA)(CN)Br]?

   A) +3
   B) +5
   C) +6
   D) +1

23. What is the coordination number of manganese, Mn, in the complex ion [Mn(en)(C₂O₄)(CO)₂]⁻?

   A) 6
   B) 3
   C) 4
   D) 8

24. What is the name of the coordination compound [Fe(NH₃)₃(CO)₃(NO₃)₃]?

   A) Triamminetricarbonyliron(III) nitrate
   B) Iron(III) triamminetricarbonyl nitrate
   C) Iron(III)trisamminetriscarbonyl trinitrate
   D) Triamminetricarbonylferrate(III) nitrate
25. What is the formula of dichlorobis(ethylenediamine)platinum(IV) sulfate?

A) Pt[en]_2Cl_2]SO_4  
B) [Pt(en)_2Cl_2]SO_4  
C) [Pt(en)_2Cl_2]_2SO_4  
D) [Pt(en)_2Cl_2(SO_4)]

26. Predict the number of unpaired electrons in the two octahedral complex ions [PdI_6]^{3-} and [Pd(CO)_4(CN)_2], respectively?

Note: I^- is a weak-field ligand, whereas CO and CN^- are strong-field ligands.

A) 4, 0  
B) 5, 1  
C) 3, 2  
D) 4, 2

27. How many isomers exist for the square planar species Pt(H_2O)(NH_3)ClBr?

A) 1  
B) 2  
C) 4  
D) 3
28. A radioactive substance undergoes decay as follows:

<table>
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<th>Time (days)</th>
<th>Mass (g)</th>
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<tr>
<td>1</td>
<td>389</td>
</tr>
<tr>
<td>2</td>
<td>303</td>
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<tr>
<td>3</td>
<td>236</td>
</tr>
<tr>
<td>4</td>
<td>184</td>
</tr>
</tbody>
</table>

The half-life of the reaction of the first-order decay is:

A) 5.56 day  
B) 2.76 day  
C) 1.39 day  
D) 0.67 day

29. An isotope with a high value of \( n/p \) will tend to decay through

A) \( \alpha \) decay  
B) \( \beta \) decay  
C) electron capture  
D) \( \gamma \) decay

30. What nuclide is formed when \( ^{238}_{92} \text{U} \) undergoes the decay series: alpha, beta, beta, alpha, alpha, alpha?

A) \( ^{222}_{86} \text{Rn} \)  
B) \( ^{226}_{88} \text{Ra} \)  
C) \( ^{230}_{90} \text{Th} \)  
D) \( ^{206}_{82} \text{Pb} \)
31. The term “critical mass” means the…
   A) Amount of fissionable material which will self-sustain a nuclear chain reaction
   B) Differences between mass of individual protons and neutrons and the mass of nucleus
   C) Energy which holds the nucleus together
   D) Mass of fuel in a nuclear reactor core

32. Calculate the energy released in joules when one mole of polonium-214 decays according to the equation

\[
{^{214}_{84}}\text{Po} \rightarrow {^{210}_{82}}\text{Pb} + {^4_2}\text{He}
\]

[Atomic masses: \( \text{Pb-210} = 209.98284 \text{ amu, Po-214} = 213.99519 \text{ amu, He-4} = 4.00260 \text{ amu, 1 amu} = 1.66053892 \times 10^{-27} \text{ kg } ], \ [1 \text{ J} = \text{kg.m}^2/\text{s}^2] 

A) \( 8.78 \times 10^{14} \text{ J/mol} \)
B) \( -9.75 \times 10^{-3} \text{ J/mol} \)
C) \( 7.2 \times 10^{14} \text{ J/mol} \)
D) \( 8.78 \times 10^{11} \text{ J/mol} \)

33. A redox reaction employed in an electrochemical cell has a negative \( \Delta G^{\circ}_{\text{rxn}} \). Which of the following must be true:
   A) \( E^{\circ} \) is positive, \( K < 1 \)
   B) \( E^{\circ} \) is positive, \( K > 1 \)
   C) \( E^{\circ} \) is negative, \( K < 1 \)
   D) \( E^{\circ} \) is negative, \( K > 1 \)

34. A galvanic cell employs the following reaction,

\[
{\text{Sn}^{2+}(aq)} + \text{Mn}(s) \rightarrow \text{Sn}(s) + {\text{Mn}^{2+}(aq)}
\]

Calculate the cell potential at 25 °C if \([\text{Sn}^{2+}] = 0.010 \text{ M}, [\text{Mn}^{2+}] = 2.00 \text{ M}. \)
\( (E^{\circ}_{\text{Sn}^{2+/\text{Sn}}} = -0.14 \text{ V}, E^{\circ}_{\text{Mn}^{2+/\text{Mn}}} = -1.18 \text{ V}) \)

A) \( +0.97 \)
B) \(-0.97 \)
C) \( +1.11 \)
D) \(-1.11 \)
35. Which of the following metals, if coated onto iron, would prevent the corrosion of iron

\[
\begin{align*}
\text{Ag}^+ + e^- & \rightarrow \text{Ag}(s) \quad E^o = +0.80 \text{ V} \\
\text{Fe}^{2+} + 2e^- & \rightarrow \text{Fe}(s) \quad E^o = -0.44 \text{ V} \\
\text{Cu}^{2+} + 2e^- & \rightarrow \text{Cu}(s) \quad E^o = +0.34 \text{ V} \\
\text{Zn}^{2+} + 2e^- & \rightarrow \text{Zn}(s) \quad E^o = -0.76 \text{ V} \\
\text{Sn}^{2+} + 2e^- & \rightarrow \text{Sn}(s) \quad E^o = -0.14 \text{ V}
\end{align*}
\]

A) Zn  
B) Ag  
C) Cu  
D) Sn

36. Which one of these molecules cannot serve as a monomer for an addition polymer?

A) ClCH=CH_2  
B) H_2C=CH–CN  
C)  
\[
\begin{align*}
\text{CH}_3 \\
\text{CH}_2=\text{C}–\text{CH}=\text{CH}_2
\end{align*}
\]

D)  
\[
\begin{align*}
\text{CH}_3–\text{C}–\text{OH}
\end{align*}
\]

37. What is the process called to prepare a ceramic by heating a slurry of a powder of an inorganic substance in water to a very high temperature under pressure?

A) Sintering  
B) Roasting  
C) Firing  
D) Sol-gel

38. Two-dimensional sheets of \(sp^2\)-hybridized carbon atoms are called:

A) graphenes  
B) diamond  
C) fullerenes  
D) carbon nanotubes
39. Which of the following combination of elements would be expected to produce a semiconductor?

A) Ga and Se  
B) As and N  
C) B and P  
D) Zn and Sb

40. Which of the following molecules is likely to form a liquid crystalline phase?

A)  
B)  
C)  
D)  

41. Which of the following statements best describes the relationship between the two structures shown?

A) They are the same compound.  
B) They are constitutional isomers.  
C) They are geometric isomers.  
D) They are stereoisomers.

42. Which one of the following is considered a pair of constitutional isomers?

A) 2-bromo-3,4-dimethylhexane & 3-bromooctane  
B) 3-bromo-4-ethylhexane & 2-methyl-3-bromohexane  
C) 3-methyl-5-bromoheptane & 3-methyl-4-bromohexane  
D) 3-bromo-4-ethylhexane & 2-bromo-2-methylhexane
43. Which of the labeled atoms in the following structure are $sp^2$ hybridized?

A) 2, 3 and 4  
B) 3 and 4  
C) 2 and 4  
D) 2 and 3

44. Which of these pairs are geometric isomers?

A) $\text{CH}_3\text{CH}_2\text{O}–\text{CH}_2\text{CH}_3$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$

B) $\text{CH}_3\text{CH}_2\text{C}–\text{CH}$ and $\text{CH}_3\text{–C}–\text{C}–\text{CH}_2\text{Cl}$

C) $\text{ClCH}_2\text{C}–\text{C}–\text{H}$ and $\text{ClCH}_2\text{–C}–\text{C}–\text{H}$

D) $\text{Cl}$ and $\text{CH}_3\text{–C}–\text{CH}_2\text{–CH}_3$
# PERIODIC TABLE OF THE ELEMENTS

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*Ce 140.12 | Pr 140.91 | Nd 144.24 | Pm 145.54 | Sm 150.36 | Eu 151.96 | Tb 157.25 | Dy 162.50 | Ho 164.93 | Er 167.26 | Tm 168.93 | Yb 173.04 | Lu 174.97 |

**Th 232.04 | Pa 231.04 | U 238.03 | Np 237 | Pu 244 | Am 243 | Cm 247 | Bk 251 | Cf 252 | Es 257 | Fm 258 | Md 259 | Lr 262 |
Answer Key

1. C
2. B
3. D
4. D
5. A
6. A
7. A
8. A
9. A
10. B
11. D
12. B
13. C
14. A
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39. C
40. C
41. A
42. A
43. D
44. C