Exam No. 111 - Blue

As soon as you receive this package, fill out the first line on this page then fill out the OPSCAN as follows:

I. Fill in your LAST NAME AND FIRST INITIAL
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III. Sign your signature on the BACK of the form
IV. Print the exam # on the top margin of the OPSCAN sheet

DO NOT TURN TO PAGE 2 UNTIL YOU ARE INSTRUCTED TO DO SO!!!!!!!

You will have 50 minutes to complete the exam; however, it shouldn’t require nearly that much time, so check your answers carefully. There are 25 multiple-choice questions; each is worth 4 points. The maximum possible score is 100 points. Please bubble one answer only, in pencil, in the appropriate question row on your OPSCAN sheet.

You will find a periodic table attached at the end of this booklet. All equations and formulas you may require are shown below.

When you are done with the exam, please return the OPSCAN and exam to the instructor or one of his proctors. **You may not keep this exam booklet.** If asked to do so, show your student ID to a proctor or instructor. You should bring your ID to every exam.

**Useful equations and constants**

\[
N = \text{Avogadro's number} = 6.02 \times 10^{23} \text{ particles/mol}
\]
\[
R = 0.08206 \text{ (L atm)/(mol K)} = 8.314 \text{ J/(mol K)}
\]
\[
1 \text{ atm} = 760 \text{ torr} = 1.01325 \times 10^5 \text{ Pa}
\]
\[
PV = nRT
\]
\[
P = \frac{nRT}{V - nb} - \frac{n^2a}{V^2}
\]
\[
E = \frac{3}{2}RT
\]
\[
u = \sqrt{\frac{3RT}{M}}
\]
\[
r_A = \sqrt{\frac{M_B}{M_A}}
\]
\[
P_i = X_iP_T
\]
\[
\Delta T = K_i m
\]
\[
\pi = \frac{nRT}{V}
\]
\[
\ln[A] = -kt + \ln[A]_0
\]
\[
\frac{1}{[A]} = \frac{kt}{[A]_0} + \frac{1}{[A]_0}
\]
\[
\ln k = -\frac{E_a}{RT} + \ln A
\]
\[
t_{1/2} = \frac{ln 2}{k} \text{ (first order)}
\]
1. A stratospheric Helium balloon is inflated to 10.0 L at sea level (P = 1.00 atm) and a
temperature of 25 °C. The balloon is allowed to ascend to an altitude where the pressure
is 0.350 atm and the temperature is –40 °C. The volume of the balloon at that altitude is
______ L.

   \[
   n = \frac{P_{i}V_{i}}{RT_{i}} = \frac{10.0 \times 1.00}{0.080206 \times 298} \text{ mol, since } n \text{ is constant then}
   \]

   \[
   V_{f} = \frac{nRT_{f}}{P_{f}} = \frac{0.409 \times 0.080206 \times 233}{0.350} \text{ L} = 22.3 \text{ L}
   \]

   a) 11.2  
b) 321  
c) 22.3  
d) 19.9  
e) 4.03

2. Which of the following factors will affect the rate of a reaction?
   a) Temperature  
b) Concentration  
c) Presence of a catalyst  
d) Nature of reactants  
e) All of the above

3. Which of the following liquid substances has the largest vapor pressure at room
   temperature (22 °C)
   a) Bromine (Br₂)  
b) Water (H₂O) My exam key was wrong  
c) Acetone (H₃C-CO-CH₃) so I gave everyone credit  
d) Ethyl ether (C₄H₉-O-C₂H₅)  
e) Benzene (C₆H₆)

4. One mol of a gas is contained in a 1.0 L glass flask at STP conditions. If the temperature
   of the gas is increased to 450 °C, the pressure of the gas ________

   a) Increases 1.65 times  
b) Decreases 1.65 times  
c) Increases 2.65 times  
d) Decreases 2.65 times  
e) Remains constant

   at n, V constant : \[
   \frac{P}{T} = \text{ const } \tan \theta, \text{ then :}
   \]

   \[
   \frac{P_{i}}{T_{i}} = \frac{P_{f}}{T_{f}} \text{, then } P_{f} = \frac{P_{i}T_{f}}{T_{i}} = \frac{P_{i} \times (273 + 450)}{273} \text{ atm} = 2.65 P_{i} \text{ atm}
   \]

5. Which of the following is expected to be most soluble/miscible in chloroform (CHCl₃)?
   a) Calcium chloride (CaCl₂)  
b) Methyl alcohol (CH₃OH)  
c) Sucrose (sugar)  
d) Water (H₂O) Although chloroform is a polar molecule, its London dispersion forces are dominant.
   e) Bromine (Br₂) This makes chloroform behaves, in many cases, as a non-polar solvent. Notice that the
                   solute with the stronger London dispersion forces is Bromine and that is why is expected
                   be the most soluble.
6. According to the kinetic-molecular theory, if the temperature of a gas is decreased from 665°C to 100°C, the average kinetic energy of the gas will _____.

- a) Decrease by a factor of 6.65
- b) Increase by a factor of 6.65
- c) Decrease by a factor of 2.51
- d) Increase by a factor of 2.51
- e) Remain constant, only the velocity changes

![Kinetic energy decrease is proportional to the decrease in T (in K):](image)

\[
E_1 = \frac{T_1}{T_2}E_2 = \frac{(665 + 273)}{(100 + 273)} E_2 = 2.51E_2
\]

7. \(N_2O_5\) decomposes according to the reaction below:

\[
2 N_2O_5(g) \rightarrow 4 NO_2(g) + O_2(g)
\]

The reaction is first order with respect to \(N_2O_5\). The rate law for this reaction is given by:

- a) \(\text{rate} = k[N_2O_5]^2\)
- b) \(\frac{\Delta[N_2O_5]}{2\Delta t} = k[N_2O_5]\)
- c) \(\frac{\Delta[N_2O_5]}{\Delta t} = k[N_2O_5]^2\)
- d) \(k = [N_2O_5]\)
- e) \(\frac{\Delta[N_2O_5]}{\Delta t} = k[N_2O_5]\)

8. A solute will spontaneously dissolve in a solvent if ________________

- a) The solute-solvent intermolecular attraction is highly exothermic relative to the energy of the solute-solute and solvent-solvent interactions
- b) The degree of disorder during the solution process decreases
- c) The solute-solvent intermolecular attraction is highly endothermic relative to the sum of solute-solute and solvent-solvent interactions
- d) It can form a saturated solution
- e) The sum of solute-solute and solvent-solvent interactions is highly exothermic relative to the energy of the solute-solvent interactions

9. Of the following which one defines best the solubility product constant (\(K_{sp}\)) you measured in Laboratory #2?

- a) It is the equilibrium constant in between ions in an aqueous solution
- b) It is the equilibrium constant for the equilibrium between an ionic solid and its ions in a saturated aqueous solution
- c) It is the rate constant for the dissociation of an ionic solid in water
- d) It is the equilibrium constant for the equilibrium between a soluble solid and water
- e) Is the solubility of the solid in water
10. The mole fraction of HCl in an aqueous solution that is 35.0\% by mass in HCl is:

\[
X_{\text{HCl}} = \frac{n_{\text{HCl}}}{n_{\text{total}}} = \frac{0.960}{3.61+0.960} = 0.210
\]

11. A gas mixture containing 0.250 g of Xe, 0.250 g of F\(_2\) and 0.500 g of He is contained in a 500.0 mL aluminum cylinder at 20 \(^\circ\)C. The total pressure of the mixture is ______ kPa.

\[
p_{\text{total}} = \frac{n_{\text{total}}RT}{V} = \frac{(n_{\text{Xe}} + n_{\text{F}_2} + n_{\text{He}})RT}{V}
\]

<table>
<thead>
<tr>
<th>a) 682</th>
<th>b) 233</th>
<th>c) 960</th>
<th>d) 167</th>
<th>e) 422</th>
</tr>
</thead>
<tbody>
<tr>
<td>P_{\text{total}} = 0.140 \times 0.08206 \times 293</td>
<td>6.73 \text{ atm} \times 101.325 \text{ kPa}</td>
<td>682 \text{ kPa}</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. The solubility of a gas in water will increase with ________________

a) An increase in temperature and pressure
b) An increase in temperature and a decrease in pressure
c) An increase in pressure and a decrease in temperature
d) A decrease in temperature and pressure
e) Addition of an electrolyte

13. Calcium hydride (CaH\(_2\)) reacts with water to form hydrogen gas:

\[
\text{CaH}_2(s) + \text{H}_2\text{O}(l) \rightarrow \text{Ca(OH)}_2(aq) + 2 \text{H}_2(g)
\]

How many grams of CaH\(_2\) are needed to generate 50.0 L of H\(_2\) with a pressure of 925 torr at 35 \(^\circ\)C?

<table>
<thead>
<tr>
<th>a) 65.8 g</th>
<th>b) 22.5 g</th>
<th>c) 91.7 g</th>
<th>d) 50.7 g</th>
<th>e) 18.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>n_{\text{H}_2} = \frac{PV}{RT} = \frac{1.22 \times 50.0}{0.08206 \times 308} = 2.41 \text{ mol}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mass \text{CaH}_2 = 2.41 \text{ mol H}_2 \times \frac{1 \text{ mol CaH}_2}{2 \text{ mol H}_2} \times \frac{42.10 \text{ g CaH}_2}{1 \text{ mol CaH}_2} = 50.7 \text{ g}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14. Of the following aqueous solutions, which one will have the largest boiling point?

a) 0.10 m Glucose non-electrolyte, \(m_{\text{effective}} = 0.10 \text{ m}\)
b) 0.10 m NaCl electrolyte, \(m_{\text{effective}} = 2 \text{ ions x 0.10 m} = 0.20 \text{ m}\)
c) 0.10 m CaCl\(_2\) electrolyte, \(m_{\text{effective}} = 3 \text{ ions x 0.10 m} = 0.30 \text{ m}\)
d) 0.10 m NH\(_4\)Cl electrolyte, \(m_{\text{effective}} = 2 \text{ ions x 0.10 m} = 0.20 \text{ m}\)
e) 0.10 m Ethanol non-electrolyte, \(m_{\text{effective}} = 0.10 \text{ m}\)

since \(\Delta T = K_m \times \text{effective}\), the larger is \(m\), the larger is b.p.
15. The iodide ion reacts with hypochlorite ion according to the reaction:

\[ \text{I}^-(aq) + \text{OCl}^-(aq) \rightarrow \text{IO}^-(aq) + \text{Cl}^-(aq) \]

The following data was collected in an experiment:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>[OCl(^-)] (M)</th>
<th>[I(^-)] (M)</th>
<th>Initial Rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5 x 10(^{-3})</td>
<td>1.5 x 10(^{-3})</td>
<td>1.4 x 10(^{-4})</td>
</tr>
<tr>
<td>2</td>
<td>3.0 x 10(^{-3})</td>
<td>1.5 x 10(^{-3})</td>
<td>2.8 x 10(^{-4})</td>
</tr>
<tr>
<td>3</td>
<td>1.5 x 10(^{-3})</td>
<td>3.0 x 10(^{-3})</td>
<td>2.8 x 10(^{-4})</td>
</tr>
</tbody>
</table>

According to these data, the rate law for the reaction is:

a) Rate = k[OCl\(^-\)][I\(^-\)]

b) Rate = k[OCl\(^-\)]\(^2\)[I\(^-\)]

c) Rate = k[OCl\(^-\)]\(^2\)[I\(^-\)]

d) Rate = k[OCl\(^-\)]

e) Rate = k[OCl\(^-\)][I\(^-\)]

16. The density of a given gas at STP conditions is 6.522 g/L. Which of the following is the gas?

a) CH\(_4\)

b) SF\(_6\)

c) N\(_2\)O\(_5\)

d) CF\(_4\)

e) C\(_2\)H\(_4\)

17. Below is the phase diagram of a given substance. The black point symbolizes which of the following:

![Phase Diagram]

a) Normal melting point

b) Triple point

c) Critical point

d) Normal boiling point

e) Supercritical point
18. Some foods take shorter to cook at high pressure than at atmospheric pressure because

a) The partial pressure of water is smaller at high pressure
b) Water boils at a higher temperature at high pressure than at atmospheric pressure
c) There is no enough cold water at high pressure
d) The viscosity of water decreases at high pressure
e) Water boils at a lower temperature at high pressure than at atmospheric pressure

19. Given there is 1.00 mol of each of the following in a 5.0 L vessel at 298 K, which gas would have the largest average kinetic energy?

a) SF₄
b) O₂
c) NH₃
d) CO₂
e) All have the same kinetic energy

20. The van der Waals equation represents the behavior of real gases taking into account that

a) Molecules have volume
b) Molecules have volume and experience attractive interactions with each other
c) Molecules repel each other
d) Molecules attract each other
e) Molecules have negligible volumes and do not interact with each other

21. Nitrogen oxide and bromine reacts according to:

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

The rate of disappearance of \( \text{Br}_2 \) is related to the rate of appearance of NOBr as:

a) \( -\frac{\Delta [\text{Br}_2]}{\Delta t} = -\frac{\Delta [\text{NOBr}]}{\Delta t} \)
b) \( -\frac{\Delta [\text{Br}_2]}{\Delta t} = \frac{\Delta [\text{NOBr}]}{2\Delta t} \)
c) \( -\frac{\Delta [\text{Br}_2]}{2\Delta t} = \frac{\Delta [\text{NOBr}]}{\Delta t} \)
d) \( -\frac{\Delta [\text{Br}_2]}{\Delta t} = \frac{\Delta [\text{NOBr}]}{\Delta t} \)
e) \( -\frac{\Delta [\text{Br}_2]}{\Delta t} = \frac{2\Delta [\text{NOBr}]}{\Delta t} \)
22. A solution is prepared by dissolving 1.025 g of an unknown (non-electrolyte) in water to a total volume of 20.0 mL. The osmotic pressure of the solution is 5.45 atm at 20 °C. The molar mass of the unknown compound is ____ g/mol

a) 189  
\[ \Pi = \frac{nRT}{V} = \frac{mRT}{(MM)V} \]

b) 1250

c) 226

d) 95.5

e) 485

\[ MM = \frac{mRT}{PV} = \frac{1.025 \times 0.08206 \times 293}{5.45 \times 0.0200} = 226 \text{ g/mol} \]

23. One mol of each of the gases below are contained in a 2.0 L reservoir capped with a microporous membrane at 298 K. The gas that would escape the fastest from the container is ________

a) Methane (CH₄) This is the lightest gas
b) Acetylene (C₂H₂)
c) Butane (C₄H₁₀)
d) Sulfur dioxide (SO₂)
e) Carbon monoxide (CO)

24. Two pans of water are on different burners of a stove. One pan of water is boiling vigorously, while the other one is boiling gently. Based on this observation, it can be said that _______________________________

a) The temperature of the water boiling gently is the smallest
b) The vapor pressure is higher in the water boiling vigorously
c) The pressure above the liquid is different than the atmospheric pressure
d) The temperature of the water in both pans is the same
e) The vapor pressure of water in both pans of water is the same

25. Hydrogen peroxide decomposes according to:

\[ \text{H}_₂\text{O}_₂(\text{aq}) \rightarrow \text{H}_₂\text{O}(l) + \frac{1}{2} \text{O}_₂(g) \]

The reaction is first order with respect to the [H₂O₂]. It can be said that the concentration of H₂O₂ will decay as a function of time in which of the following manner?

a) Inverse: \[ \frac{1}{[\text{H}_₂\text{O}_₂]} = kt + C \]
b) Linear: \[ [\text{H}_₂\text{O}_₂] = kt + C \]
c) Exponential: \[ [\text{H}_₂\text{O}_₂] = Ce^{-kt} \]
d) Square: \[ [\text{H}_₂\text{O}_₂]^2 = kt + C \]
e) Inverse square: \[ \frac{1}{[\text{H}_₂\text{O}_₂]^2} = kt + C \]