University of Saskatchewan
Department of Chemistry
CHEMISTRY 112.3 Term I
Midterm Examination
October 15, 2016 (10 AM - noon)

Last Name (please print clearly!)__________________________________________

First Name (please print clearly!)__________________________________________

Student Number________________________Signature________________________________

Please indicate your section:

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<tr>
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<td>MWF 8:30 AM</td>
<td>K. Brown</td>
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<td>03</td>
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INSTRUCTIONS - PLEASE READ THIS FIRST!

1. This is a closed-book examination. A data-sheet with a periodic table is attached to the back of this paper; you may detach this and keep it. Use the margins and backs of pages for working. **No other paper is required or permitted.**
2. Use the periodic table found at the back of this exam to answer questions, rather than the periodic table on the wall of the exam wall (if any).
3. Simple scientific calculators are permitted. **Alphanumeric calculators and those capable of storing equations are not permitted.** Cell phones, personal digital assistants, electronic dictionaries, etc. are not allowed.
4. This examination paper has **10** pages, including the data sheet. To ensure that your copy is complete, and to become familiar with the questions, please **read through the entire examination before you answer any questions.**
5. Questions are worth 2.5 marks each. Total marks: **100.**
6. Before starting the examination, fill out the top of this Question Paper and of the opscan sheet, and code your NSID on the opscan sheet in HB pencil. **At the end of the examination, place the opscan sheet on top of this Question Paper and hand in both together.**
1. What is the unit of temperature in SI base units?
   a.) Second
   b.) Celsius
   c.) Meter
   d.) Kelvin
   e.) Fahrenheit

2. Calculate the following equation to the correct number of significant figures:
   \[
   \frac{1.400 \times 10^6 + 0.000069}{0.7 \times 10^6 - 0.000045}
   \]
   a.) 2
   b.) 2.0
   c.) 2.001
   d.) 1.96 \times 10^6
   e.) 2.001 \times 10^6

3. How many significant figures are in each measurement?
   i.) 3.25 \times 10^6
   ii.) 0.005367
   iii.) 3.4078
   iv.) 0.0000003
   a.) 7, 4, 4, 1
   b.) 3, 6, 5, 7
   c.) 7, 4, 5, 7
   d.) 3, 4, 5, 1
   e.) 3, 4, 5, 7

4. A cubic block of pure metal with edges 3.0 cm long weighs 522 g. Which of the following metals was the block made from?
   a.) Mg, density 1.74 g cm\(^{-3}\)
   b.) Fe, density 7.87 g cm\(^{-3}\)
   c.) Pb, density 11.34 g cm\(^{-3}\)
   d.) Au, density 19.32 g cm\(^{-3}\)
   e.) Rb, density 1.63 g cm\(^{-3}\)

5. The atomic weight of chlorine is very close to 35.5. This means that
   a.) Chlorine occurs with a variable number of protons
   b.) A variable number of electrons give the fractional weight
   c.) On the average, an atom of chlorine weighs about 3 times as much as carbon
   d.) The actual weight of a chlorine atom is not known precisely
   e.) Chlorine atoms contain half a proton.
6. The formula for the oxide of strontium is:
   a.) SrO
   b.) SrO₂
   c.) Sr₂O₃
   d.) SrO₃
   e.) Sr₂O₄

7. A new element, Saskatoonium (Sk), has recently been discovered and consists of two isotopes. One isotope has a mass of 331 g/mol and is 35.0 % abundant. The other isotope is 337 g/mole. What is the mass of Sk as it appears on the periodic table?
   a.) 332 g/mol
   b.) 333 g/mol
   c.) 334 g/mol
   d.) 335 g/mol
   e.) 336 g/mol

8. The number of oxygen atoms in 1.80 moles of sucrose, C₁₂H₂₂O₁₁, is:
   a.) 3.48 x 10²²
   b.) 1.39 x 10²⁵
   c.) 1.19 x 10²⁵
   d.) 2.38 x 10²⁴
   e.) 4.88 x 10²⁴

9. From the symbol $^{40}_{19}K^+$ we can say that this isotope of potassium has
   a.) 19 electrons, 19 protons and 19 neutrons
   b.) 19 electrons, 40 protons and 19 neutrons
   c.) 18 electrons, 40 protons and 19 neutrons
   d.) 18 electrons, 19 protons and 21 neutrons
   e.) 1 electron, 19 protons and 21 neutrons

10. Dalton’s atomic theory is based on several assumptions which are listed below. Which of these assumptions is strictly correct in modern atomic theory?
   I.) All atoms of the same element are identical
   II.) Atoms are indivisible and identical
   III.) Chemical changes are the result of the combination, separation and rearrangement of atoms

   a.) I, II and III are correct
   b.) I and III are correct
   c.) II and III are correct
   d.) I and II are correct
   e.) III is correct
11. A 7.92 g sample of K₂CrO₄ has what mass of Cr in it?
   a.) 3.19 g
   b.) 2.61 g
   c.) 2.12 g
   d.) 1.98 g
   e.) 0.268 g

12. For a 1.00 g sample of each of the following compounds, which sample will have the most molecules in it?
   a.) CH₄
   b.) CO₂
   c.) SCl₂
   d.) KNO₃
   e.) C₆H₁₂C₆

13. An element in the periodic table that has similar chemistry (properties, ion charge, compound formulas etc.) to that of calcium is:
   a.) Cl
   b.) Ne
   c.) Cs
   d.) Fe
   e.) Sr

14. Give the name for KClO₄.
   a.) potassium perchlorate
   b.) potassium hyperchlorite
   c.) potassium chlorite
   d.) potassium chlorate
   e.) phosphorous perchlorate

15. Determine the name for CoCl₂·6H₂O.
   a.) cobalt chloride hydrate
   b.) cobalt (I) chloride heptahydrate
   c.) cobalt (II) chloride heptahydrate
   d.) cobalt (II) chloride hexahydrate
   e.) cobalt (I) chloride

16. How many moles of N₂O₄ are in 76.3 g N₂O₄?
   a.) 7.02 x 10³ moles
   b.) 1.42 x 10⁻⁴ moles
   c.) 1.00 mole
   d.) 1.21 moles
   e.) 0.829 moles
17. Calculate the mass percent composition of lithium in Li₃PO₄.
   a.) 26.75 %
   b.) 17.98 %
   c.) 30.72 %
   d.) 55.27 %
   e.) 20.82 %

18. How many molecules of butane are contained in 25.0 mL of butane? The density of butane is 0.6011 g/mL and the molar mass is 58.12 g/mol.
   a.) 2.59 × 10²³ molecules butane
   b.) 1.46 × 10²⁷ molecules butane
   c.) 6.87 × 10²³ molecules butane
   d.) 1.56 × 10²³ molecules butane
   e.) 7.14 × 10²⁵ molecules butane

19. Determine the molecular formula of a compound that has a molar mass of 92.0 g/mol and an empirical formula of NO₂.
   a.) N₂O₃
   b.) N₃O₆
   c.) N₂O₄
   d.) NO₂
   e.) N₂O₅

20. Determine the molecular formula of a compound that is 49.48% carbon, 5.19% hydrogen, 28.85% nitrogen, and 16.48% oxygen. The molecular weight is 194.19 g/mol.
   a.) C₈H₁₂N₄O₂
   b.) C₄H₅N₂O
   c.) C₈H₁₀N₄O₂
   d.) C₈H₁₀N₂O
   e.) C₆H₈N₃O

21. Write a balanced equation to show the reaction of gaseous ethane (C₂H₆) with gaseous oxygen to form carbon monoxide gas and water vapor.
   a.) 2 C₂H₆(g) + 7 O₂(g) → 4 CO₂(g) + 6 H₂O(g)
   b.) C₂H₆(g) + 5 O₂(g) → 2 CO(g) + 3 H₂O(g)
   c.) 2 C₂H₆(g) + 5 O₂(g) → 4 CO(g) + 6 H₂O(g)
   d.) C₂H₆(g) + 7 O₂(g) → 2 CO₂(g) + 3 H₂O(g)
   e.) 2 CH₃(g) + 5 O(g) → 2 CO(g) + 3 H₂O(g)
22. Which of the following is an ionic compound?
   a.) SF$_2$
   b.) Mg$_3$(PO$_4$)$_2$
   c.) Cl$_2$O
   d.) CH$_2$O
   e.) PBr$_5$

23. Ethane (C$_2$H$_6$, M = 30.06 g/mol) reacts with bromine (Br$_2$, M = 159.80 g/mol) to form bromoethane, (C$_2$H$_5$Br, M = 108.97 g/mol) and HBr (H = 80.91 g/mol). How many grams of bromoethane are formed when 10.0 g of ethane and 10.0 g of bromine are reacted?
   a.) 6.82 g
   b.) 36.2 g
   c.) 20.0 g
   d.) 10.0 g
   e.) 29.4 g

   \[ 3 \text{Fe(s)} + 4 \text{H}_2\text{O(g)} \rightarrow \text{Fe}_3\text{O}_4(s) + 4 \text{H}_2(g) \]

   If the reaction of 6.0 mol Fe with an excess of H$_2$O produces 5.6 mol of H$_2$, what is the theoretical yield and % yield?
   a.) theoretical yield is 8 mol H$_2$; % yield is 70%
   b.) theoretical yield is 7 mol H$_2$; % yield is 80%
   c.) theoretical yield is 6 mol H$_2$; % yield is 93%
   d.) theoretical yield is 9 mol H$_2$; % yield is 62%
   e.) theoretical yield is 10 mol H$_2$; % yield is 56%

25. What number of moles of O$_2$ is needed to produce 14.2 grams of P$_4$O$_{10}$ according to the following reaction?
   \[ \text{P}_4(s) + 5 \text{O}_2(g) \rightarrow \text{P}_4\text{O}_{10}(s) \]
   a.) 0.0500 mol
   b.) 0.0625 mol
   c.) 0.125 mol
   d.) 0.250 mol
   e.) 0.500 mol

26. If 87 grams of K$_2$SO$_4$ (molar mass 174 g/mol) is dissolved in enough water to make 250 milliliters of solution, what are the concentrations of the potassium and the sulfate ions?
   a.) K$^+$ 0.40 M, SO$_4^{2-}$ 0.20 M
   b.) K$^+$ 1.0 M, SO$_4^{2-}$ 2.0 M
   c.) K$^+$ 2.0 M, SO$_4^{2-}$ 1.0 M
   d.) K$^+$ 2.0 M, SO$_4^{2-}$ 2.0 M

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e.) $K^+ 4.0 \text{ M, } SO_4^{2-} 2.0 \text{ M}$

27. Which NaOH solution has the highest concentration?
   a.) 1 mol of NaOH dissolved in 1 L of solution
   b.) 2 mol of NaOH dissolved in 3 L of solution
   c.) 240 g of NaOH dissolved in 4 L of solution
   d.) 160 g of NaOH dissolved in 8 L of solution
   e.) 3 mol of NaOH dissolved in 4 L of solution

28. Concentrated aqueous perchloric acid (HClO₄) solution has a molarity of 11.7 M. How many mL of this solution are needed to prepare 1.00 L of 1.00 M of HClO₄.
   a.) 100 mL
   b.) 171 mL
   c.) 85.5 mL
   d.) 200 mL
   e.) 11.7 mL

29. How many grams of NaHCO₃ (baking soda) would you need to neutralize 500.0 mL of battery acid (H₂SO₄) that has been spilled on a garage floor? The concentration of sulfuric acid is 12.00 molar.
   \[ H_2SO_4\text{(aq)} + 2\text{NaHCO}_3\text{(s)} \rightarrow Na_2SO_4\text{(aq)} + 2\text{CO}_2\text{(g)} + 2\text{H}_2O \]
   a.) 1,008 kg
   b.) 1,008 g
   c.) 504 g
   d.) 252 g
   e.) 12 g

30. What are the spectator ions in the precipitation reaction between MgCl₂(aq) and K₂CO₃(aq)?
   a.) Mg²⁺ and Cl⁻
   b.) Mg²⁺ and CO₃²⁻
   c.) Cl⁻ and K⁺
   d.) K⁺ and CO₃²⁻
   e.) no reaction

31. The oxidation state of zinc in a reaction increases by 2. This indicates that:
   a.) zinc is reduced and loses 2 electrons
   b.) zinc is reduced and gains 2 electrons
   c.) zinc is oxidized and loses 2 electrons
   d.) zinc is oxidized and gains 2 electrons
   e.) none of the above
32. Identify the oxidizing and reducing agent in the following redox reaction.

\[ \text{Fe}_2\text{O}_3(s) + 3 \text{CO}(g) \rightarrow 2 \text{Fe}(l) + 3 \text{CO}_2(g) \]

a.) Fe$_2$O$_3$, CO  
b.) Fe$_2$O$_3$, Fe  
c.) CO, CO$_2$  
d.) Fe, CO$_2$  
e.) Fe, CO

33. What is the density of chlorine gas at 1.00 atm and 298 K?

a.) 1.58 g/L  
b.) 1.73 g/L  
c.) 2.90 g/L  
d.) 3.16 g/L  
e.) 3.45 g/L

34. A gas sample has a pressure of 2.16 atm. The temperature (in K) of the sample is increased by a factor of three, and it is compressed to half its previous volume. Assuming ideality, the pressure is now

a.) 0.360 atm.  
b.) 13.0 atm.  
c.) 3.24 atm.  
d.) 1.14 atm.  
e.) Cannot answer without more information

35. Write the net ionic equation for the reaction of barium chloride and sodium sulfate.

a.) BaCl$^2$(aq) + NaSO$_4$ (aq) \rightarrow BaSO$_4$ (s) + NaCl (aq)  
b.) BaCl$^2$ (aq) + SO$_4^{2-}$ (aq) \rightarrow BaSO$_4$ (s) + Ba$^{2+}$ (aq)  
c.) Ba$^{2+}$ (aq) + SO$_4^{2-}$ (aq) \rightarrow BaSO$_4$ (aq)  
d.) Na$^+$ (aq) + Cl$^-$ (aq) \rightarrow NaCl (aq)  
e.) Ba$^{2+}$ (aq) + SO$_4^{2-}$ (aq) \rightarrow BaSO$_4$ (s)

36. In which of the following pairs is the oxidation number for the underlined element incorrect?

a.) ClO$_4^-$ / 7  
b.) S$_2$O$_3^{2-}$ / 2  
c.) Fe$_2$O$_3$ /3  
d.) HCO$_3^-$ / 3  
e.) CO$_2$ / 4
37. Which statement correctly compares a real gas and an ideal gas?
   a.) At high pressures, the volume of a mole of a real gas is higher than predicted by the ideal gas law.
   b.) Intermolecular attractions will cause the pressure of a real gas to be higher than the ideal gas law would predict.
   c.) The volume of a mole of a real gas is always equal to that predicted by the ideal gas law.
   d.) All of the above statements are correct.
   e.) None of the above statements is correct.

38. A sample of oxygen gas is collected over water at 23°C at a barometric pressure of 751 mmHg. The vapour pressure of water at 23°C is 21 mmHg. The partial pressure of oxygen gas in the sample collected is:
   a.) 0.96 atm
   b.) 21 mmHg
   c.) 751 mmHg
   d.) 1.02 atm
   e.) 44 mmHg

39. A glass vessel weighing 40.1305 g has a volume of 98.5 mL. It is filled with an unknown gas at 772 mmHg at 22.4°C. If the vessel filled with gas weighs 40.4868 g, what is the molar mass of the gas?
   a.) 86.4 g/mol
   b.) 97.8 g/mol
   c.) 14.7 g/mol
   d.) 12.9 g/mol
   e.) 1.18 x10^2 g/mol

40. What is the total pressure, in atmospheres, of a 10.0 L container that contains 2.00 moles of nitrogen gas at 27°C? Assume ideal gas behavior.
   a.) 24.6 atm
   b.) 4.92 atm
   c.) 2,460 atm
   d.) 4,920 atm
   e.) 4.43 atm
### Physical Constants

<table>
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<tr>
<th>Constant</th>
<th>Symbol</th>
<th>Value</th>
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<tbody>
<tr>
<td>Atomic mass unit</td>
<td>( \mu )</td>
<td>( 1.6605 \times 10^{-27} ) kg</td>
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<tr>
<td>Avogadro number</td>
<td>( N_A )</td>
<td>( 6.0221 \times 10^{23} ) mol(^{-1} )</td>
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<td>Gas Constant</td>
<td>( R )</td>
<td>( 0.082058 ) L atm mol(^{-1}) K(^{-1} )</td>
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<td></td>
<td></td>
<td>( 8.3145 ) J K(^{-1} ) mol(^{-1} )</td>
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<td></td>
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<td>( 62.364 ) L mmHg mol(^{-1}) K(^{-1} )</td>
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<td>Molar volume of an ideal gas at STP</td>
<td>( V_m )</td>
<td>( 22.414 ) L mol(^{-1} )</td>
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<tr>
<td>Electron mass</td>
<td>( m_e )</td>
<td>( 9.109 \times 10^{-31} ) Kg</td>
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### Some SI Derived Units

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<th>Unit</th>
<th>Symbol</th>
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<td>Force</td>
<td>Newton</td>
<td>( N )</td>
<td>kg m s(^{-2} )</td>
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<tr>
<td>Energy</td>
<td>Joule</td>
<td>( J )</td>
<td>kg m(^2) s(^{-2} )</td>
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<tr>
<td>Pressure</td>
<td>Pascal</td>
<td>( Pa )</td>
<td>N m(^{-2} ) = kg m(^{-1}) s(^{-2} )</td>
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**STP Conditions:** 
\[ P = 1 \text{ atm} = 760 \text{ torr} = 760 \text{ mmHg} = 101.325 \text{ kPa} \]
\[ T = 0 \text{ °C} = 273.15 \text{ K} \]