INSTRUCTIONS - PLEASE READ THIS FIRST!

1. This is a closed-book examination. A data-sheet with a Periodic Table is attached to the last page of this examination paper (you can remove this page from the booklet for convenience)

2. 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. No equations may be stored in memory of electronic devices.

3. This examination paper has 11 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.

4. You can use the backside of each page as scratch paper.

5. A total of 100 marks can be obtained. Each of the 40 questions will be weighted with 2.5 marks each. You should spend an average of 3 minutes on each question.

6. Please fill out the top of this paper and the top of the op-scan sheet. Print your name and code your student number in soft pencil and make sure to note the exam version on the op-scan sheet.

7. Answer these questions by circling the response on this paper AND by filling out the corresponding response on the opscan sheet USING A SOFT-LEAD PENCIL ONLY. No deductions will be made for incorrect answers, but multiple answers will be treated as NO answer. If you change your mind, erase the incorrect answer carefully from the optical scan sheet. In the event of a discrepancy, the response on the opscan sheet will count.

8. HAND-IN ALL of your material (question sheet and computer sheet)

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</table>
1. Calculate the following equation to the correct number of significant figures.

\[
\frac{5.00}{1.235} + 3.045 + \frac{6.35}{4.1} =
\]

a) 8.64238
b) 8.6423
c) 8.642
d) 8.64
e) 8.6

2. In the SI unit system, the prefix “pico” means

a) \(10^{-9}\)
b) \(10^9\)
c) \(10^{12}\)
d) \(10^{-12}\)
e) \(10^{-6}\)

3. Express 0.000640 in scientific notation.

a) \(6.40 \times 10^{-3}\)
b) \(6.40 \times 10^4\)
c) \(6.40 \times 10^{-4}\)
d) \(6.4 \times 10^4\)
e) \(6.4 \times 10^{-4}\)

4. If a can of soup contains 22.0 oz (ounces) of soup, how many grams of soup is that? (1.00 lb (pound) = 16.0 oz; 1.00 lb = 454 g)

a) 0.0485 g
b) 20.6 g
c) 330 g
d) 523 g
e) 624 g

5. A beaker has a mass of 112 g. When 25 mL of a liquid sample is poured into the beaker, the mass of the beaker and the liquid sample together is 134 g. What is the density of the liquid sample?

a) 0.44 g/mL
b) 0.88 g/mL
c) 1.1 g/mL
d) 1.2 g/mL
e) 2.4 g/mL
6. Which of the following is a correct feature of the nuclear atom proposed by Rutherford?

   a) All atoms of an element have the same mass
   b) It is like the “plum pudding” model
   c) The number of neutrons and electrons in the atom are the same
   d) All alpha particles to strike the gold foil “bounced back”
   e) The atom is mostly empty space

7. Which of the following elements can be classified as nonmetals: Fe, Cl, Al, Li, F, Na, K, S

   a) Na, K, Li
   b) Fe, Al, S
   c) Cl, F, S
   d) Na, Fe Cl
   e) F, S, K

8. How many protons, electrons, and neutrons are in $^{138}\text{Ba}^{2+}$?

   a) 56 protons, 54 electrons, 138 neutrons
   b) 56 protons, 54 electrons, 82 neutrons
   c) 82 protons, 80 electrons, 56 neutrons
   d) 56 protons, 56 electrons, 82 neutrons
   e) 82 protons, 82 electrons, 82 neutrons

9. A hypothetical element, Z, has two stable isotopes:

   Z-38: isotopic mass = 38.012 g/mol; isotopic abundance = 75.68%;
   Z-46: isotopic mass = 45.981 g/mol; isotopic abundance = 24.32%.

   The element's atomic mass would be closest to which of the following elements?

   a) Potassium (K)
   b) Scandium (Sc)
   c) Calcium (Ca)
   d) Argon (Ar)
   e) Sodium (Na)

10. What is the atomic mass of an element if 4.00 grams of it contains $2.98 \times 10^{22}$ atoms?

    a) 20.2 g/mol
    b) 80.8 g/mol
    c) 19.7 g/mol
    d) 8.08 g/mol
    e) 2.02 g/mol
11. How many atoms of lead (Pb) are required to cover a 33.0 cm by 45.0 cm area with a sheet of lead that is 0.0140 cm thick? The density of lead is 11.35 g/cm$^3$.

a) $1.42 \times 10^{26}$
b) $6.86 \times 10^{22}$
c) $2.29 \times 10^{25}$
d) $6.86 \times 10^{23}$
e) $2.29 \times 10^{26}$

12. Consider each formula and name pair:

- $KNO_3$ (s) Potassium nitrate
- $SO_2$ (g) Sulfur monoxide
- $NaClO_4$ (s) Sodium perchlorate
- $P_4O_{10}$ (s) Phosphorous oxide
- $SF_6$ (g) Sulfur hexafluoride

How many of these pairs are **CORRECT**?

a) None of these combinations are correct
b) 2 of these combinations are correct
c) 3 of these combinations are correct
d) 4 of these combinations are correct
e) 5 of these combinations are correct

13. Consider each formula and name pair:

- $HNO_3$ (aq) Nitric acid
- $H_2SO_3$ (aq) Sulfuric acid
- $HCl$ (g) Hydrochloric acid
- $HF$ (aq) Hydrofluoric acid
- $NaClO_3$ (aq) Chloric acid

How many of these pairs are **CORRECT**?

a) None of these combinations are correct
b) 2 of these combinations are correct
c) 3 of these combinations are correct
d) 4 of these combinations are correct
e) 5 of these combinations are correct
14. Which compound is **INCORRECTLY** named?

a) \( \text{Cr}_2\text{O}_3 \): chromium (III) oxide  
b) \( \text{CaSO}_4 \cdot 2\text{H}_2\text{O} \): calcium sulfate dihydrate  
c) \( \text{TiO}_2 \): titanium (IV) oxide  
d) \( \text{Fe}_2(\text{SO}_4)_3 \): iron (III) sulfate  
e) \( \text{Co(NO}_3)_2 \cdot 6\text{H}_2\text{O} \): cobalt (III) nitrate heptahydrate

15. Which sample contains the largest number of molecules?

a) 1.0 g ethanol (\( \text{C}_2\text{H}_5\text{OH} \))  
b) 1.0 g acetone (\( \text{CH}_3\text{COCH}_3 \))  
c) 1.0 g \( \text{CH}_4 \)  
d) 1.0 g HCN  
e) 1.0 g \( \text{H}_2\text{O} \)

16. How much water is present in 83.0 g of \( \text{Li}_3\text{PO}_4 \cdot 12\text{H}_2\text{O} \)?

a) 0.250 mol  
b) 0.717 mol  
c) 2.61 mol  
d) 3.00 mol  
e) none of these

17. Naphthalene, commonly found in mothballs, is 93.75% carbon and 6.25% hydrogen by mass. The molar mass is 128 g/mol. What is the molecular formula for naphthalene?

a) \( \text{C}_5\text{H}_4 \)  
b) \( \text{C}_9\text{H}_4\text{O} \)  
c) \( \text{CH}_15 \)  
d) \( \text{C}_{10}\text{H}_8 \)  
e) \( \text{C}_9\text{H}_{20} \)

18. Cumene is known to contain only hydrogen and carbon. The burning of a sample of cumene produced 0.32 moles of \( \text{CO}_2 \) and 0.215 moles of \( \text{H}_2\text{O} \) vapour. What is the empirical formula of cumene?

a) \( \text{C}_3\text{H}_4 \)  
b) \( \text{C}_3\text{H}_2 \)  
c) \( \text{CH}_8 \)  
d) \( \text{CH} \)  
e) \( \text{C}_2\text{H}_3\text{O}_2 \)
19. What is the mass percent of carbon in ethanol (CH₃CH₂OH)?

a) 52.1  
b) 46.1  
c) 34.7  
d) 86.9  
e) 13.2

20. For the reaction shown below, what is the maximum mass (in grams) of ammonia (NH₃) that can be formed from 7.83 g of N₂H₄?

\[ 3 \text{N}_2\text{H}_4(\ell) \rightarrow 4 \text{NH}_3(g) + \text{N}_2(g) \]

a) 4.16 g  
b) 3.12 g  
c) 1.38 g  
d) 5.55 g  
e) 5.87 g

21. 18.4 g of iron(III) oxide reacts with 11.6 g of carbon monoxide according to the balanced equation below. What is the theoretical yield of solid elemental iron, Fe(s)?

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

a) 15.4 g  
b) 6.43 g  
c) 18.2 g  
d) 23.1 g  
e) 12.9 g

22. 624 mmol of Mg reacts with 431 mmol of O₂ gas according to the equation below. Assuming the limiting reagent reacts completely, how much of the excess reagent (in mmol) is left unreacted?

\[ \text{Mg(s)} + \text{O}_2(g) \rightarrow \text{MgO(s)} \] (unbalanced)

a) 119 mmol  
b) 410 mmol  
c) 194 mmol  
d) 313 mmol  
e) 237 mmol
23. What is the percent yield of the following reaction if 2.47 g of Na produces 2.13 g of NaBr? Assume that Br₂ is in excess.

\[ 2 \text{Na}(s) + \text{Br}_2(g) \rightarrow 2 \text{NaBr}(s) \]

a) 43.1 %  
b) 19.3 %  
c) 22.4 %  
d) 38.5 %  
e) 86.2 %

24. 2.00 mL of a 0.60 M Na₂SO₄(aq) solution is diluted to a final volume of 150.0 mL. What is the molarity (i.e., concentration) of Na⁺ in the final solution?

a) 4.5 M  
b) 0.016 M  
c) 0.090 M  
d) 0.0080 M  
e) 1.2 M

25. What mass of solid Na₂CO₃ is required to make 250.0 mL of a 0.125 M solution of Na₂CO₃?

a) 2.59 g  
b) 30.2 g  
c) 21.2 g  
d) 3.31 g  
e) 2.81 g

26. How many of the following compounds are electrolytes: CO₂, KBr, HCl, H₂SO₃?

a) 0  
b) 1  
c) 2  
d) 3  
e) 4

27. Which, if any, of the following chemical reactions is a precipitation reaction?

a) \( \text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} \)  
b) \( \text{CH}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \)  
c) \( \text{Na} + \text{Cl}_2 \rightarrow \text{NaCl} \)  
d) \( 2\text{N}_2\text{O} \rightarrow 2\text{N}_2 + \text{O}_2 \)  
e) None of the above
28. For the following reaction, the net ionic equation is:

\[ \text{Pb(NO}_3\text{)}_2(aq) + \text{Na}_2\text{S(aq)} \rightarrow \text{PbS(s) + 2NaNO}_3(aq) \]

a) \( \text{Na}^+(aq) + \text{NO}_3^-(aq) \rightarrow \text{NaNO}_3(aq) \)
b) \( \text{Pb}^{2+}(aq) + \text{S}^2-(aq) \rightarrow \text{PbS(s)} \)
c) \( \text{Pb(NO}_3\text{)}_2(aq) + \text{S}^2-(aq) \rightarrow \text{PbS(s) + 2NO}_3(aq) \)
d) \( \text{Pb}^{2+}(aq) + \text{Na}_2\text{S(aq)} \rightarrow 2\text{Na}^+(aq) + \text{PbS(s)} \)
e) None of the above

29. Calculate the concentration of 20.00 ml of \( \text{H}_2\text{SO}_4 \) needed to neutralize 21.33 ml of a \( \text{NaOH} \) solution having a concentration of 0.60 M.

\[ \text{H}_2\text{SO}_4(aq) + \text{NaOH(aq)} \rightarrow \text{H}_2\text{O(l)} + \text{Na}_2\text{SO}_4(aq) \text{ (unbalanced)} \]

a) 0.64 M  
b) 0.59 M  
c) 0.32 M  
d) 0.23 M  
e) 0.031 M

30. The oxidation number of manganese in \( \text{Mn}_2\text{O}_3 \) is:

a) +1  
b) +2  
c) +3  
d) +4  
e) +5

31. Which of the following reactions is an oxidation-reduction reaction?

a) \( 2 \text{H}_3\text{PO}_4(aq) + 3 \text{BaO(aq)} \rightarrow \text{Ba}_3(\text{PO}_4)_2(aq) + 3 \text{H}_2\text{O(l)} \)
b) \( \text{Pb(NO}_3\text{)}_2(aq) + 2 \text{CsI(aq)} \rightarrow \text{Pbl}_2(s) + 2 \text{CsNO}_3(aq) \)
c) \( \text{H}_2\text{SO}_4(aq) + \text{Ca(OH)}_2(aq) \rightarrow \text{CaSO}_4(s) + 2 \text{H}_2\text{O(l)} \)
d) \( \text{CaF}_2(s) + \text{H}_2\text{SO}_4(l) \rightarrow 2 \text{HF(g)} + \text{CaSO}_4(s) \)
e) \( \text{C}_6\text{H}_12\text{S(l) + 20 O}_2(g) \rightarrow 6 \text{CO}_2(g) + 6 \text{H}_2\text{O(g) + SO}_2(g) \)

32. Identify the oxidizing agent in the following redox reaction.

\[ 2\text{Fe(OH)}_2^+(aq) + \text{Mn}^{2+}(aq) \rightarrow \text{MnO}_2(s) + 2\text{Fe}^{2+}(aq) + 2\text{H}_2\text{O(l)} \]

a) \( \text{Fe(OH)}_2^+ \)
b) \( \text{Mn}^{2+} \)
c) \( \text{MnO}_2 \)
d) \( \text{Fe}^{2+} \)
e) \( \text{H}_2\text{O} \)
33. Which one of the following reactions yields a gas?

a) \( \text{LiNO}_3 + \text{KBr} \rightarrow \)

b) \( \text{HNO}_3 + \text{NH}_3 \rightarrow \)

c) \( \text{Cu}^{2+} + 2\text{Cl}^- \rightarrow \)

d) \( \text{NaNO}_3 + \text{NaBr} \rightarrow \)

e) \( \text{CaCO}_3 + 2\text{HBr} \rightarrow \)

34. Which statement below correctly describes Charles’ Law?

a) For a fixed amount of gas at a constant temperature, the gas volume is inversely proportional to gas pressure.

b) For a fixed amount of gas at constant pressure, the volume is directly proportional to the temperature.

b) For a fixed temperature and pressure, the volume of a gas is directly proportional to the number of gas molecules.

d) For a fixed amount of gas at constant volume, the gas pressure is directly proportional to the temperature.

e) None of the above statements correctly describe Charles’ Law.

35. Using the ideal gas law \( (PV = nRT) \), calculate the density in g/L of a sample of F\(_2\)(g) that has a pressure of 0.83 atm and a temperature of 27.0 °C. (NOTE: Density \( (d) = \frac{m\text{(mass)}}{V\text{(volume)}} \).)

a) 0.64 g/L

b) 1.4 g/L

c) 0.35 g/L

d) 1.3 g/L

e) 14 g/L

36. For the following gas evolution reaction, calculate the mols of HCl(aq) required to produce a sample of CO\(_2\)(g) having a pressure of 1.0 atm, a temperature of 298 K, and a volume of 1.5 L. Assume that K\(_2\)CO\(_3\)(aq) is present in excess.

\[ 2\text{HCl(aq)} + \text{K}_2\text{CO}_3\text{(aq)} \rightarrow \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)} + 2\text{KCl(aq)} \]

a) 0.031 mols

b) 0.061 mols

c) 0.12 mols

d) 0.18 mols

e) 0.24 mols
37. Air primarily contains N\textsubscript{2}(g) and O\textsubscript{2}(g). Calculate the mass of O\textsubscript{2}(g) in a sample of air that contains 0.40 mols of N\textsubscript{2}(g) and has a total volume of 11.2 L under STP (standard temperature and pressure) conditions. Assume that no other gases are present in the air sample.

a) 3.2 g  
b) 6.4 g  
c) 9.6 g  
d) 13 g  
e) 16 g

38. A system contains three gases: 2.00 moles of N\textsubscript{2}(g), 1.00 moles of He(g), and 0.50 moles of O\textsubscript{2}(g). What is the partial pressure of N\textsubscript{2}(g) if the total pressure of the system is 4.30 atm?

a) 0.614 atm  
b) 4.30 atm  
c) 1.23 atm  
d) 2.46 atm  
e) 1.84 atm

39. A sample of H\textsubscript{2}(g) is collected over water and the total pressure of the collected gas sample is found to be 0.650 atm. Calculate the mols of H\textsubscript{2}(g) present in the gas sample if the partial pressure of water vapour is 0.0316 atm at 298 K and the total volume of the gas sample is 2.00 L.

a) 0.00532 mols  
b) 0.0506 mols  
c) 0.00258 mols  
d) 0.0532 mols  
e) 0.0604 mols

40. Which statement properly describes the difference between a real gas and an ideal gas?

a) The molar volume of a real gas is larger than predicted by the ideal gas law at high pressures  
b) Intermolecular attractions make the real pressure greater than the ideal gas law would predict at low temperatures  
c) The molar volume of a real gas is always equal to that predicted by the ideal gas law.  
d) All of these statements are correct  
e) None of these statements are correct
### Periodic Table of the Elements

#### Physical Constants

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<tr>
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<th>Symbol</th>
<th>Value</th>
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<tr>
<td>Atomic mass unit</td>
<td>( m )</td>
<td>( 1.6605 \times 10^{-27} ) kg</td>
</tr>
<tr>
<td>Avogadro number</td>
<td>( N_A )</td>
<td>( 6.0221 \times 10^{23} ) mol(^{-1} )</td>
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<tr>
<td>Gas Constant</td>
<td>( R )</td>
<td>0.08206 L atm mol(^{-1})K(^{-1})</td>
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<td></td>
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<td>8.3145 J K(^{-1})mol(^{-1})</td>
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<td>62.364 L mmHg mol(^{-1})K(^{-1})</td>
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<tr>
<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>Symbol</th>
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<tr>
<td>Force</td>
<td>Newton</td>
<td>N</td>
<td>kg m s(^{-1})</td>
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<tr>
<td>Energy</td>
<td>Joule</td>
<td>J</td>
<td>kg m(^{2}) s(^{-2})</td>
</tr>
<tr>
<td>Pressure</td>
<td>Pascal</td>
<td>Pa</td>
<td>N m(^{-2}) = kg m(^{1}) s(^{-2})</td>
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</tbody>
</table>

**STP Conditions:**

\( P = 1 \) atm = 760 torr = 760 mmHg = 101.325 kPa  
Temperature = 0 °C = 273.15 K