This exam consists of 27 + 2 EC questions on 7 pages

This all-multiple choice question exam will be automatically graded using a bubble sheet. Fill in the corresponding bubbles completely and dark enough to be read by the scanner. The answer you fill in on your bubble sheet is the one that will be scored. You can circle the answer on this exam booklet for your own reference, only. Questions are printed on both sides of each page. The last sheet of the exam contains some useful information and can be used as scratch paper. It must be turned in with your exam!

If you do not correctly bubble-in your ISU email ID and your recitation section number, your exam score will NOT get uploaded into blackboard gradebook and you will receive a score of ‘0’. Do not use mechanical pencils. #2 pencils are highly recommended.

Regrade Policy: Graded exam will be returned to you during Thursday recitation. If you have request for regrade, you MUST submit your exam to your TA before leaving the recitation room.
Question 1. Which one of the following quantities has 3 significant figures?

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<thead>
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<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>24.5 °C</td>
<td>0.0013 kg</td>
<td>1500 kJ</td>
<td>0.08206 L·atm/mol·K</td>
</tr>
</tbody>
</table>

Question 2. Which of the following is a chemical property of an unknown sample?

- A density
- B mass
- C melting point
- D heat capacity
- E % carbon by mass

Question 3. Co-60 is used medically for radiation therapy. The nuclei of these isotopes have ___ protons and ___ neutrons.

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<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>27, 60</td>
<td>27, 33</td>
<td>27, 31.9</td>
<td>33, 27</td>
</tr>
<tr>
<td>E</td>
<td>58.9, 27</td>
<td></td>
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</table>

Question 4. The systematic name for SO₃(g) is_________.

- A sulfur oxide
- B monosulfur trioxide
- C sulfur(III) oxide
- D sulfur trioxide
- E sulfur peroxide

Question 5. The correct formula for magnesium phosphide is

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<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>MgP</td>
<td>MnP₂</td>
<td>Mg₂P</td>
<td>Mn₂P₃</td>
</tr>
<tr>
<td>E</td>
<td>Mg₃P₂</td>
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Question 6. What is the empirical formula of a compound that contains 29% Na, 41% S, and 30% O by mass?

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<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>NaSO₃</td>
<td>NaSO₂</td>
<td>NaSO</td>
<td>Na₂S₂O₃</td>
</tr>
<tr>
<td>E</td>
<td>Na₂S₂O₆</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Question 7. A 3.82-g sample of magnesium nitride (MM 100.9 g/mol) is reacted with an excess of water.

\[
\text{Mg}_3\text{N}_2 + 3\text{H}_2\text{O} \rightarrow 2\text{NH}_3 + 3\text{MgO}
\]

The actual yield of MgO (MM 40.3 g/mol) is 3.60 g. What is the percent yield in the reaction?

A 78.7 %
B 49.4 %
C 62.5 %
D 46.6 %
E 94.5 %

Question 8. What are the spectator ions in the reaction between AgNO₃(aq) and KCl(aq)?

A K⁺ and Cl⁻
B Ag⁺ and NO₃⁻
C Ag⁺ and Cl⁻
D K⁺ and NO₃⁻
E NO₃⁻ only

Question 9. The correct name for HClO₄(aq) is __________.

A hypochlorous acid
B chlorous acid
C hydrochloric acid
D chloric acid
E perchloric acid

Question 10. Which one of the following is a weak acid?

A nitric acid
B perchloric acid
C hydrobromic acid
D hydrofluoric acid
E sulfuric acid

Question 11. What is the concentration in mol/L of CH₃OH in a solution prepared by dissolving 11.7 g of CH₃OH (MM 32.04 g/mol) in sufficient water to give exactly 230 mL of solution?

A 11.9 M
B 1.59 M
C 0.0841 M
D 11.9 × 10⁻³ M
E 1.59 × 10⁻³ M
Question 12. In which species does nitrogen have the highest oxidation number?

A NaNO₃  B NO₂⁻  C HNO₂  D N₂  E NH₃

Question 13. The thermochemical equation of the decomposition of methanol is given below:

\[
\text{CH}_3\text{OH}(l) \rightarrow \text{CO}(g) + 2\text{H}_2(g) \quad \Delta H^\circ = +128.1 \text{ kJ/mol}
\]

How many kJ of heat are consumed when 15.5 g of CH₃OH(l) (MM 32.04 g/mol) decomposes as shown in the equation?

A 0.48  B 8.3  C 32  D 62.0  E 1.3 \times 10^2

Question 14. Calculate the enthalpy of combustion for acetone in kJ/mol from the enthalpies of formation given.

\[
\text{C}_3\text{H}_6\text{O}(l) + 4 \text{O}_2(g) \rightarrow 3 \text{CO}_2(g) + 3 \text{H}_2\text{O}(l)
\]

<table>
<thead>
<tr>
<th>compound</th>
<th>C₃H₆O(l)</th>
<th>CO₂(g)</th>
<th>H₂O(l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔH°r in kJ/mol</td>
<td>–248</td>
<td>–393.5</td>
<td>–285.8</td>
</tr>
</tbody>
</table>

A –1790  B –1370  C 1370  D 1790  E 3580

Question 15. The _______-quantum number(s) determine(s) the orientation of an atomic orbital.

A principal (n),  B angular momentum (l),  C magnetic, (m_l)  D angular momentum (l) and spin (m_s)  E magnetic (m_l) and spin (m_s)
Question 16. A mole of red photons of wavelength 725 nm has _______ kJ of energy.

A \(2.74 \times 10^{-19}\)
B \(4.56 \times 10^{-46}\)
C \(6.05 \times 10^{-3}\)
D 165
E 227

Question 17. The ground-state electron configuration an atom of _______ is [Ar] 4s\(^2\) 3d\(^5\).

A V, vanadium
B Mn, manganese
C Fe, iron
D Cr, chromium
E Ca, calcium

Question 18. Of the choices below, which gives the correct order of increasing atomic radii?

A Ar < Cl < S < Si < Al
B Al < Si < S < Cl < Ar
C S < Si < Cl < Al < Ar
D Cl < S < Al < Si < Ar
E Cl < S < Al < Ar < Si

Question 19. The reaction of a metal with a nonmetal always produces a(n) __________.

A oxide
B ionic compound
C hydroxide
D base
E acid

Question 20. What is the electron configuration of an iron(II) cation, Fe\(^{2+}\)?

A [Ar] 4s\(^2\) 3d\(^6\)
B [Ar] 4s\(^2\) 3d\(^4\)
C [Ar] 3d\(^6\)
D [Ar] 4s\(^2\) 4d\(^6\)
E [Ne] 4s\(^2\) 3d\(^6\)

Question 21. Based on the positions of calcium and sulfur in the periodic table, calcium sulfide is expected to be _______ and would have a _______ melting point.

A ionic, low
B covalent, low
C ionic, high
D covalent, high
E polar covalent, low
Question 22. In the molecule below, which bond is the most polar bond?

\[ \text{F} = \text{Cl} \]
\[ \text{C} = \text{C} \]
\[ \text{I} \quad \text{Br} \]

A  C – C  
B  C – F  
C  C – Cl  
D  C – Br  
E  C – I

Question 23. How many *equivalent resonance* forms can be drawn for the carbonate ion, \( \text{CO}_3^{2-} \)? (Carbon is the central atom.)

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<tbody>
<tr>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
</tr>
</tbody>
</table>

Question 24. The bond enthalpy \( (D) \) is defined as the enthalpy of reaction in which a covalent bond is broken. *Example:* \( \text{Cl}_2(g) \rightarrow 2 \text{Cl}(g) \). \( \Delta \text{H}_{\text{rxn}} = 242 \text{ kJ/mol} = D(\text{Cl} – \text{Cl}) \)

Breaking bonds is ___________ and bond enthalpy is ______________.

<p>| | |</p>
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<tr>
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<tbody>
<tr>
<td>A</td>
<td>always endothermic, always positive</td>
</tr>
<tr>
<td>B</td>
<td>always exothermic, always positive</td>
</tr>
<tr>
<td>C</td>
<td>always endothermic, always negative</td>
</tr>
<tr>
<td>D</td>
<td>always exothermic, always negative</td>
</tr>
<tr>
<td>E</td>
<td>sometimes endothermic and sometimes exothermic, sometimes positive and sometimes negative</td>
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</tbody>
</table>

Question 25. The molecular geometry of the \( \text{BF}_3 \) molecule is __________, and this molecule is __________.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>A</td>
<td>trigonal planar, polar</td>
</tr>
<tr>
<td>B</td>
<td><strong>trigonal planar, nonpolar</strong></td>
</tr>
<tr>
<td>C</td>
<td>trigonal pyramidal, polar</td>
</tr>
<tr>
<td>D</td>
<td>trigonal pyramidal, nonpolar</td>
</tr>
<tr>
<td>E</td>
<td>T-shaped, nonpolar</td>
</tr>
</tbody>
</table>
Question 26. The molecule shown below has ____ sigma bonds and ____ pi bonds.

![Molecule Diagram]

A 4, 3  
B 7, 3  
C 4, 6  
D 10, 0  
E 7, 6

Question 27. What volume (in L) of sulfur dioxide can be produced by the complete reaction of 3.82 g of calcium sulfite (MM 120.2 g/mol) with excess HCl(aq), when the final SO₂ pressure is 1.09 atm at 44.0 °C? Assume ideal gas behavior.

\[
\text{CaSO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{SO}_2(g) + \text{CaCl}_2(aq) + \text{H}_2\text{O}(l)
\]

A \(1.39 \times 10^{-7}\)  
B \(1.00 \times 10^{-6}\)  
C \(1.06 \times 10^{-4}\)  
D \(5.78 \times 10^{-1}\)  
E \(7.60 \times 10^{-1}\)

Question 28. The molar volume of an ideal gas at STP is _________ L.

A 0.08206  
B 62.36  
C 1.00  
D 22.4  
E 14.7
**Question 29.** A mixture of He, Ne, and Ar has a total pressure of 6.70 atm. What is the mole fraction of Ne if the partial pressures of He and Ar are 1.60 atm and 2.80 atm, respectively.

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
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<tbody>
<tr>
<td>A</td>
<td>0.174</td>
</tr>
<tr>
<td>B</td>
<td>0.256</td>
</tr>
<tr>
<td>C</td>
<td>0.343</td>
</tr>
<tr>
<td>D</td>
<td>0.481</td>
</tr>
<tr>
<td>E</td>
<td>0.570</td>
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**Question 30.** A balloon is filled with nitrogen gas at 20°C. Which one of the following will *decrease* as the temperature of the balloon is raised to 50°C at constant pressure?

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>the average kinetic energy of the molecules</td>
</tr>
<tr>
<td>B</td>
<td>the root-mean-square speed of the molecules</td>
</tr>
<tr>
<td>C</td>
<td>the strength of the impact of an average molecule with the container wall</td>
</tr>
<tr>
<td>D</td>
<td>the density of the gas</td>
</tr>
<tr>
<td>E</td>
<td>the volume of the balloon</td>
</tr>
</tbody>
</table>