Science Olympiad
Eastside Invitational
Stevenson High School
2017

Chemistry Lab
Part 1 – Written Exam
Part 2 – Lab Component

Read the directions below. Do not start the test until you have been instructed to do so.

• You may write on this test.
• You may separate this test into multiple sections.
• Only answers recorded on the scantron will be graded.
• You will find reference pages at the beginning of the test that you may refer to at any point during
  the test or lab.
• All pages of this test must be stapled together and returned at the end of the testing period.

Team Number: ________
School/Team: _____________________________________________________________
Student Names: ____________________________________________________________
### Table 1

<table>
<thead>
<tr>
<th>Substance</th>
<th>$q$ (L·atm/mol)</th>
<th>$v$ (L/mol)</th>
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### Table 2

**Water (1/°C)**  
Latent Heat of **Table 2.**

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- **Changes (kJ/mol)**
- **Water Phase**
### VAPOUR PRESSURE OF WATER

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<th>P (torr)</th>
<th>T (°C)</th>
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Science Olympiad – Chemistry Lab
Part 1 – Written Test

Multiple Choice – Select the best answer for each below. Be sure to transfer your answers to the scantron.

1. Which of the following statements about gases is not true?
   a. Gases can be easily compressed
   b. The distance between gas molecules is large
   c. Gases can form homogenous mixtures
   d. Gases will expand to fill their container
   e. **All gases are colorless and odorless under standard conditions**

2. A gas sample at constant temperature has a volume of 250 mL and 3.50 atm. What volume will the sample occupy if the pressure is changed to 1.55 atm?
   a. 111 mL
   b. 217 mL
   c. 565 mL
   d. 1.36 L
   e. 5.65 L

3. A sealed balloon will break if its volume reaches 4.50 L. At 20°C, the volume of the balloon is 3.79 L. At what temperature will the balloon break if the pressure stays the same?
   a. 17°C
   b. 24°C
   c. 26°C
   d. 51°C
   e. 75°C

4. How many moles of a gas occupy 2.67 L at 2.3 atm and 25°C?
   a. $2.5 \times 10^{-3}$ mol
   b. 0.030 mol
   c. **0.25 mol**
   d. 3.0 mol
   e. 4.0 mol

5. Which of the following gases would have the highest average molecular speed at 25°C?
   a. O₂
   b. N₂
   c. CO₂
   d. CH₄
   e. SF₆

6. In the van der Waals equation, the constants “a” and “b” are
   a. **Used to correct for the finite volume of gas molecules and the attractive forces between gas molecules**
   b. Equal to each other for any real gas
   c. Used to correct for the difference between Celsius and Kelvin
   d. Equal to 1 for ideal gases
   e. Used to correct for the fact that collisions of gas molecules are not really completely elastic

7. The vapor pressure of a liquid will decrease if
   a. The volume of the vapor above the liquid is increased
   b. The volume of the liquid is decreased
   c. **The temperature is decreased**
   d. The surface area of the liquid is decreased
   e. A more volatile liquid is added
8. Which of the following statements is/are true?
   I. Deviations in the behavior of gases from the ideal-gas equation occur because gas molecules occupy a finite volume in a container
   II. Deviations in the behavior of gases from the ideal-gas equation occur because attractions between gas molecules exist
   III. Deviations in the behavior of gases from the ideal-gas equation decrease with increasing temperature
   a. I only
   b. II only
   c. I and II
   d. II and III
   e. I, II, and III

9. How much heat is required to convert 100 g of water at 40°C to water vapor at 100°C?
   a. 227 kJ
   b. 418 kJ
   c. 226 kJ
   d. 25.1 kJ
   e. 251 kJ

10. A chemist uses a cylinder with a piston and gas inlet valve. Consider the following change: Inject an additional gas through the gas inlet valve. What will be the consequences for the pressure of the gas and for the number of moles of gas present?
    a. The pressure of the gas will decrease, and the number of moles of gas present will decrease
    b. **The pressure of the gas will increase, and the number of moles of gas present will increase**
    c. The pressure of the gas will decrease, and the number of moles of gas present will increase
    d. There will be no changes in the pressure of the gas or in the number of moles
    e. The number of moles will stay the same, and the pressure of the gas will decrease

11. According to the ideal-gas equation, which of the following statements is true?
    a. If gases are mixed, the partial pressure of each lowers the partial pressure of the others
    b. For Boyle’s law to apply, a gas must be kept at constant pressure
    c. The volume of a gas is not changed if it is heated from 0°C to 100°C and at the same volume if the pressure is increased from 750 torr to 850 torr
    d. The volume of a gas doubles when the centigrade temperature doubles if all other variables are held constant
    e. **The volume of a gas decreases by a factor of 2 when the pressure is doubled if all other variables are held constant**

12. At STP, 20. Microliters of O₂ contain 5.4 x 10¹⁶ molecules. How many molecules are in 20. microliters of N₂?
    a. 5.4 x 10¹⁵
    b. 1.0 x 10¹⁶
    c. 2.7 x 10¹⁶
    d. 5.4 x 10¹⁶

13. A blimp is filled with 5000. L of helium at 28.0°C and 99.7 kPa. What is the mass of helium used?
    a. 797 g
    b. 810. g
    c. 879 g
    d. 8.57 x 10³ g

14. What is the density of nitrogen gas at STP?
    a. 0.62 g/L
    b. 1.14 g/L
    c. **1.25 g/L**
    d. 2.03 g/L
15. Find the volume of methane that will produce 12 L of hydrogen in the reaction below. Assume temperature and pressure remain constant.

\[ \text{CH}_4(g) + \text{H}_2\text{O}(g) \rightarrow \text{CO}(g) + \text{H}_2(g) \]

a. \(4.0\) L
b. \(12\) L
c. \(24\) L
d. \(36\) L

16. What is the partial pressure of oxygen, in torr, in the atmosphere when the atmospheric pressure is 760.0 torr?

<table>
<thead>
<tr>
<th>Components of Air</th>
<th>Mole Fraction</th>
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</thead>
<tbody>
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<tr>
<td>Oxygen</td>
<td>0.209</td>
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<tr>
<td>Argon</td>
<td>0.010</td>
</tr>
</tbody>
</table>

a. \(159\)
b. \(430\)
c. \(601\)
d. \(720\)
e. \(760\)

17. A gas is heated in a sealed container. Which of the following occur?

a. Gas pressure rises
b. Gas density decreases
c. The average distance between molecules increases
d. All of the above

18. A \(\Delta H\) corresponds to a \(\Delta H^\circ\) process. Select all that are true.

a. Negative; endothermic
b. Negative; exothermic
c. Positive; exothermic
d. Positive; endothermic
e. Zero; exothermic

19. An amount of heat equal to 3500 J is released from a system. In addition, 1500 J of work is done by the system on the surroundings. What is the change in internal energy of the system?

a. \(1500\) J
b. \(2000\) J
c. \(3500\) J
d. \(5000\) J
e. \(-5000\) J

20. \(\Delta H^\circ\) for the reaction below is \(-482\) kJ. Calculate the heat released when 12.0 g of \(\text{CO}(g)\) reacts completely, according to the following chemical equation:

\[ 2\text{CO}(g) + \text{O}_2(g) \rightarrow 2\text{CO}_2(g) \]

a. \(2.89 \times 10^3\) kJ
b. \(206\) kJ
c. \(103\) kJ
d. \(65.7\) kJ
e. \(-482\) kJ

21. What is the specific heat of iron if 13.5 J is required to raise the temperature of a 10-g sample by 3 K?

a. \(0.45\) J/g-K
b. \(2.22\) J/g-K
c. \(4.05\) J/g-K
d. \(45\) J/g-K
e. \(405\) J/g-K
22. For which of the species in the following chemical reaction is the enthalpy of formation equal to zero?

\[ 2\text{Co(s)} + \text{H}_2(\text{g}) + 8\text{PF}_3(\text{g}) \rightarrow 2\text{HCo(PF}_3)_4(\text{l}) \]

- a. Co(s)
- b. H\(_2\)(g)
- c. PF\(_3\)(g)
- d. HCo(PF\(_3\))\(_4\)(l)
- e. Both Co(s) and H\(_2\)(g)

23. What is the standard heat of combustion of CH\(_4\)(g)? Use the following data:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Standard Heat of Formation (kJ/mol)</th>
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</thead>
<tbody>
<tr>
<td>CH(_4)(g)</td>
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<tr>
<td>CO(_2)(g)</td>
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<tr>
<td>H(_2)O(l)</td>
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</table>

- a. -890.3 kJ/mol
- b. -604.6 kJ/mol
- c. -252.9 kJ/mol
- d. -182.5 kJ/mol

24. 10.0 kJ of heat are added to one kilogram of iron at 10. °C. What is the final temperature of the iron? The specific heat of iron is 0.45 J/g-°C.

- a. 22°C
- b. 27 °C
- c. 32 °C
- d. 37 °C

25. Ozone can be destroyed through reaction with

- a. An oxygen radical
- b. UV radiation
- c. Nitrogen gas
- d. Both a & b

26. Chlorofluorocarbons contribute to ozone depletion by

- a. Releasing chlorine radicals
- b. Directly reacting with ozone
- c. Releasing fluorine radicals
- d. Inhibiting the ability of ozone to migrate to areas of low concentration

27. Which of the following is not a common contributing reaction to ozone depletion?

- a. HO + O\(_3\) → HO\(_2\) + O\(_2\)
- b. NO + O\(_3\) → NO\(_2\) + O\(_2\)
- c. ClO + O → Cl + O\(_2\)
- d. PO\(_3\) + O → PO\(_2\) + O\(_2\)

28. CFC stands for

- a. Chlorinated Freon compound
- b. Chlorofluorocarbon
- c. Carbonated fluorine compound
- d. Caustic fluorine carbohydrate
- e. Carbofluoro compound

29. The concentration of which greenhouse gas has increased steadily over the last few decades?

- a. H\(_2\)O
- b. CO
- c. CO\(_2\)
- d. H\(_2\)O\(_2\)
- e. O\(_2\)
30. Cl atoms formed via photolysis of C-Cl bonds of CFC's in the stratosphere are particularly effective in destroying ozone at these altitudes because
   a. Cl atoms absorb UV, which generate O atoms to react with O₂ to produce ozone
   b. **Cl atoms catalytically convert O₃ to O₂**
   c. Cl atoms stoichiometrically convert O₃ to O₂
   d. Cl atoms react with H atoms, which catalyze conversion of O₂ to O₃
   e. Cl atoms react with N atoms, which catalyze conversion of O₂ to O₃

*Completion – solve the following problems. Report your answers on the scantron form in the space provided. Be sure to include units and significant figures with your final answer.*

31. A 4.22 g sample of copper (II) sulfide was added to excess hydrochloric acid, and the resulting hydrogen sulfide gas was collected over water. What volume of gas was collected at 30.5°C when the atmospheric pressure was 749 torr?

32. What is the heat change that takes place when 36.0 g of water at atmospheric pressure cools from 125°C to 40.0°C?
Science Olympiad – Chemistry Lab
Part 2 - Lab Component

**Background Information:** In this lab you will combine two solutions that react in a 1:1 ratio in order to form a product. The stoichiometry of the reaction is as follows:

\[ A + B \rightarrow C \]

**Task Details:** Use calorimetry to determine the enthalpy of reaction of the product, “C”, in kJ/mol. Assume that the calorimeter is perfectly insulating, that the specific heat of the solution is 4.184 J/(g\(
\cdot ^\circ C\)), and that the density of the solution is 1.00 g/mL. Write your final answer in the box provided at the bottom of this page with the correct sign, significant figures, and units.

**Materials List:**
- Coffee-cup calorimeter (maximum volume of ___ mL)
- Thermometer
- Solution A (___ mL max.)
- Solution B (___ mL max.)
- Graduated Cylinder
- Distilled water

**Disposal:** All solutions can be disposed of in the sink with copious amounts of water.

**Data:** Clearly record all measurements below.

**Calculations:** Clearly show all calculations below.

**Final Answer:**