Final Exam (Practice)  Chemistry 111, Prof. Metz

120 minutes
Put your name and student ID# on both pages of the answer sheet.
**Put all answers on the answer sheet - answers for questions 30-32 go on page 2.**
Turn in the entire test.
For each question, only one answer is correct.
Useful information is on page 2 of the answer sheet.
Each multiple choice question is worth 3 points.

1. The protein randomase has a molecular mass (molecular weight) of $1.6 \times 10^5$. One microgram of this protein costs $100. How many molecules of randomase are in one microgram of randomase?

A) $1.60 \times 10^{11}$  B) $3.76 \times 10^{12}$  C) $6.25 \times 10^{12}$  D) $6.02 \times 10^{17}$  E) $3.76 \times 10^{18}$

2. The percentage composition of sulfur in sodium sulfate is

A) 22.6 %  B) 25.4 %  C) 26.9 %  D) 29.8 %  E) 41.1 %

3. Consider the compound whose Lewis dot structure is drawn below (note that this is merely the Lewis dot structure - it does NOT accurately represent the bond angles in the molecule).

![Lewis dot structure](image)

The O-C-O bond angle (eg, the bond angle about the carbon atom) is labelled $\theta$. This angle is approximately

A) 45°  B) 90°  C) 109°  D) 120°  E) 180°

4. In an experiment similar to the one you did in Lab, 14.00 grams of molybdenum metal react with sulfur, producing 21.02 g of a compound containing only molybdenum and sulfur. What compound is produced?


5. Photodissociation of NO$_2$ (a major component of smog) in cities eventually leads to formation of irritants. The photodissociation $\text{NO}_2 + h\nu \rightarrow \text{NO} + \text{O}$ requires photons with a wavelength of 398 nm. This wavelength corresponds to an energy of ____ kJ/mole. (Hint: Watch the units! Find the energy in ONE photon, then calculate the energy in a MOLE of photons)

A) $5 \times 10^{-19}$  B) $5 \times 10^{-16}$  C) $5 \times 10^{-4}$  D) 0.3  E) 300
6. The oxidation number of Cr in K₂Cr₂O₇ is
A) -6       B) -1       C) 0       D) +1       E) +6

7. The electron configuration of the ion Si⁺ is
A) 1s² 2s² 2p⁶ 3s² 3p¹     B) 1s² 2s² 2p⁶ 3s² 3p²     C) 1s² 2s² 2p⁶ 3s³
D) 1s² 2s² 2p⁶ 3s² 3d³     E) 1s² 2s² 2p⁶ 3s² 3p³

8. A single atom of an element which has only one stable isotope has a mass of 8.47 x 10⁻²³ grams. What is the atomic mass of the element, in grams/mole ?
A) 14.1     B) 28.1     C) 51.0     D) 79.1     E) 84.7

9. The molecular mass ("formula weight") of magnesium hydroxide is closest to
A) 41 g/mol     B) 58 g/mol     C) 66 g/mol     D) 72 g/mol     E) 89 g/mol

10. Silane (SiH₄(g)) burns spontaneously in air, forming sand (SiO₂(s)) and water. Using the following enthalpies of reaction
    H₂(g) + 1/2 O₂(g) → H₂O(l)     ΔH = -286 kJ
    Si(s) + O₂(g) → SiO₂(s)     ΔH = -911 kJ
    Si(s) + 2 H₂(g) → SiH₄(g)     ΔH = +34 kJ
ΔH for the reaction
    SiH₄(g) + 2 O₂(g) → SiO₂(s) + 2 H₂O(l)     is
A) -1163 kJ     B) -1197 kJ     C) -1231 kJ     D) -1449 kJ     E) -1517 kJ

11. How much heat is required to convert a 50.0 gram ice cube at -10.0 °C to liquid water at 15.0 °C ?
(Hint: Use the thermodynamic information on page 2 of the answer sheet)
A) 20.8 kJ     B) 117.2 kJ     C) 19.3 kJ     D) 118.3 kJ     E) 21.9 kJ
12. Ethanol (C₂H₅OH) burns in oxygen, producing liquid water and carbon dioxide gas. If the reaction is carried out at constant pressure, for each mole of ethanol that is burned, how much heat is produced? (The enthalpy of formation of C₂H₅OH is -277.7 kJ/mole; values for other compounds are given on page 2 of the answer sheet)

A) -1644.4 kJ  B) -401.6 kJ  C) -957.0 kJ  D) -1922.1 kJ  E) -1366.7 kJ

13. Consider the transitions labelled A - E in the hydrogen atom energy level diagram on the answer sheet. Of these, the one that corresponds to absorption of a photon of the shortest (smallest) wavelength is

A) A  B) B  C) C  D) D  E) E

14. An aqueous solution of silver nitrate is combined with an aqueous solution of sodium chloride.

What happens?
A) No reaction occurs  B) sodium metal and chlorine gas are produced
C) sodium nitrate precipitates  D) silver chloride precipitates  E) silver metal is produced

15. A 19.5 gram piece of molybdenum is heated to 100.0 °C and dropped into 50.0 grams of water initially at 15.00 °C. The final temperature of the metal and the water is 16.94 °C. The heat capacity of water is 4.184 J/g•K. What is the heat capacity of molybdenum?

A) 0.0362 J/g•K  B) 0.0952 J/g•K  C) 0.237 J/g•K  D) 0.245 J/g•K  E) 0.251 J/g•K

16. An oxygen atom has ____ unpaired electrons

A) 0  B) 1  C) 2  D) 3  E) 4

17. When copper metal is inserted into a silver nitrate solution, silver is produced:

\[ \text{Cu} \text{(s)} + 2 \text{AgNO}_3 \text{(aq)} \rightarrow \text{Cu(NO}_3)_2 \text{(aq)} + 2 \text{Ag} \text{(s)} \]

If 3.14 grams of copper react completely with excess silver nitrate how much silver metal is produced?
18. Potassium reacts violently with water via the reaction
\[ 2 \text{K (s)} + 2 \text{H}_2\text{O (l)} \rightarrow \text{H}_2 \text{ (g)} + 2 \text{KOH (aq)} \]

If 2.0 g of potassium reacts with water, what volume of hydrogen is produced at 1 atm pressure and 20 °C ?
A) 0.28 L  B) 0.042 L  C) 2.44 L  D) 0.61 L  E) 1.22 L

19. A gas contains 78.14% boron and 21.86% hydrogen by weight. Its empirical formula is
A) B₃H  B) BH  C) BH₃  D) B₂H₅  E) B₂H₆

20. Automobile air bags are inflated by the decomposition of sodium azide:
\[ 2 \text{NaN}_3 \text{(s)} \rightarrow 2 \text{Na (s)} + 3 \text{N}_2 \text{(g)} \]

What mass of sodium azide (NaN₃(s)) is required to provide the nitrogen needed to inflate a 25.0 liter bag to a pressure of 1.3 atm at 25 °C ?
A) 1.33 g  B) 10.6 g  C) 15.8 g  D) 57.6 g  E) 86.3 g

21. 0.381 g of ethylene oxide gas placed in a 250 mL container at 20.0 °C produces a pressure of 0.833 atm. What is the molar mass (molecular weight) of ethylene oxide ?
A) 44 g/mole  B) 56 g/mole  C) 67 g/mole  D) 88 g/mole  E) 112 g/mole
22. Deuterium is an isotope of hydrogen with an atomic mass of 2.00 amu. The atomic symbol for deuterium is D. Since hydrogen and deuterium are chemically very similar, one of the few simple methods of separating the two isotopes relies on diffusion. This method relies on the fact that H₂ diffuses _____ times as fast as HD.
A) 0.67  B) 0.82  C) 1.22  D) 1.50  E) 2.25

23. One of the earliest methods of producing nitric acid was by reaction of sodium nitrate with sulfuric acid. If 426 g of sodium nitrate (MW=85.0) and 226 g of sulfuric acid (MW=98.1) are allowed to react, what is the maximum number of grams of nitric acid (MW=63.0) that can be produced?

\[ 2 \text{NaNO}_3 \text{(s)} + \text{H}_2\text{SO}_4 \text{(aq)} \rightarrow 2 \text{HNO}_3 \text{(aq)} + \text{Na}_2\text{SO}_4 \text{(aq)} \]
A) 290  B) 316  C) 340 g  D) 350  E) 376

24. Which of the following compounds is polar (has a dipole moment greater than zero)?
A) BF₄⁻  B) SF₄  C) CF₄  D) SiF₄  E) SF₆

25. A sample of nitrogen gas has a pressure of 31.0 mm Hg in a 100 mL container. It is transferred to a new container, at the same temperature, and is found to have a pressure of 47.6 mm Hg. The volume of the new container is approximately
A) 65 mL  B) 81 mL  C) 100 mL  D) 123 mL  E) 154 mL

26. What is the formal charge on the chlorine atom in OCIO⁻? (Make sure the Cl has an octet)
A) –2  B) –1  C) 0  D) +1  E) +2

27. When 0.355 g of a compound are placed in a 1.00 L container at 17 °C the gas produces a pressure of 189 mm Hg. What is the molar mass (molecular weight) of this compound?
A) 23 g/mole  B) 34 g/mole  C) 67 g/mole  D) 88 g/mol  E) 112 g/mole
28. 0.40 g of carbon dioxide gas pressurize a cylinder to 0.82 atm at 25 °C. What is the volume of the cylinder?
A) 105 mL  B) 180 mL  C) 270 mL  D) 380 mL  E) 510 mL

29. Extra Credit (3 points)

Polyethylene consists of repeating -CH₂- units. When stretched out, polyethylene has a length of 0.15 nm per (-CH₂-CH₂-) unit (see illustration above).

If a chemist synthesized a single polyethylene molecule long enough to just encircle the Earth, how much would this molecule weigh?

The circumference of the Earth (at the equator) is 6378 km.
A) 2 x 10⁻⁶ g  B) 9.6 x 10⁻⁴ g  C) 0.03 g  D) 47 g  E) 9 x 10¹³ g

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Answer questions 30-32 on page 2 (the page with the periodic table at the top)
Your answer MUST be on that page to be graded

30. (4 points) Draw the Lewis dot structure of XeF₄

31. (4 points) Draw the Lewis dot structure of hydrogen peroxide, HOOH
(Note: there is no central atom - the four atoms are in a row)

32. (8 points) Draw two (resonance) Lewis dot structures for the formate anion, HCO₂⁻. On one Lewis dot structure, please indicate the formal charge on each atom (write the formal charge above each atom).