

Final**Multiple Choice**

Identify the choice that best completes the statement or answers the question.

Record the test ID letter in the top right box of the scantron form.

Record your name on the top of this exam and on the scantron form.

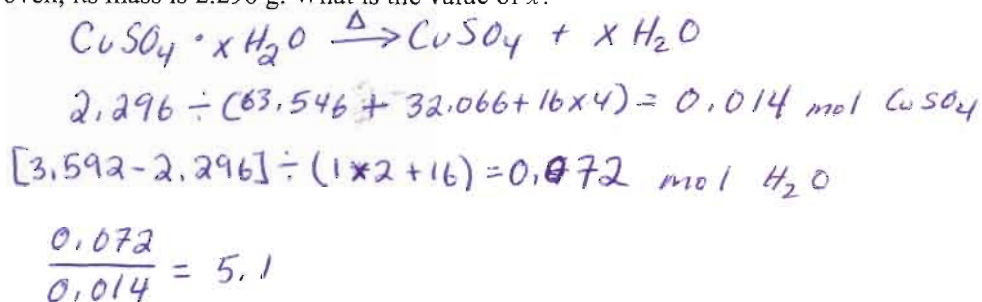
Be sure to fill out your student ID# on your scantron correctly.

Record all of your answers on the scantron form.

- _____ 1. Which species in the reaction below undergoes **reduction**?
- $$2 \text{Na(s)} + 2 \text{H}_2\text{O(aq)} \rightarrow 2 \text{Na}^+\text{(aq)} + 2 \text{OH}^-\text{(aq)} + \text{H}_2\text{(g)}$$
- a. Na
 b. H₂O Water is being reduced
 c. Na⁺
 d. OH⁻
 e. H₂
- _____ 2. How much energy (in kJ) is required to change the temperature of 1.56 kg Si from 25.0 °C to 37.5 °C? The specific heat capacity of ~~iron~~ ^{silicon} is 0.702 J/g·K.
- a. 1.54 kJ
 b. 313 kJ
 c. 13.7 kJ
 d. 13.7 × 10³ kJ
 e. 313 × 10³ kJ
- $$q = m c_{sp} \Delta T$$
- $$= (1.56 \text{ kg}) (0.702 \frac{\text{J}}{\text{g}\cdot\text{K}}) (37.5 - 25.0 \text{ } ^\circ\text{C})$$
- $$= 13.7 \text{ kJ}$$
- _____ 3. The density of liquid mercury is 13.5 g/cm³. What mass of mercury will fill a 12.0 ounce soda can? (1.00 oz = 29.6 mL, 1.00 mL = 1.00 cm³)
- a. 0.0380 g
 b. 26.3 g
 c. 4.80 × 10³ g
 d. 369 g
 e. 162 g
- $$\frac{13.5 \text{ g}}{\text{cm}^3} \times \frac{1 \text{ cm}^3}{1 \text{ mL}} \times \frac{29.6 \text{ mL}}{1 \text{ oz}} \times \frac{12 \text{ oz}}{1} = 4795 \text{ g}$$
- _____ 4. What is the ground state electron configuration for Fe³⁺?
- a. [Ar]3d⁴4s²
 b. [Ar]3d⁶4s²
 c. [Ar]3d³4s²
 d. [Ar]3d⁶
 e. [Ar]3d⁵
- Remove from 4s first
 then from 3d

5. A 3.592 g sample of hydrated copper sulfate, $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$, is dried in an oven. When the anhydrous salt is removed from the oven, its mass is 2.296 g. What is the value of x ?

- a. 1
b. 2
c. 3
d. 5
e. 6



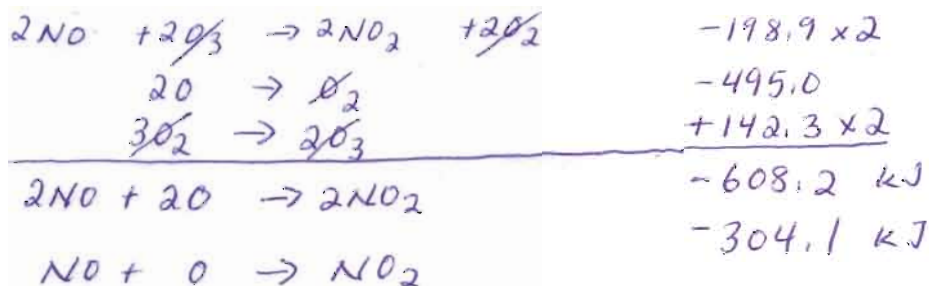
6. Determine the enthalpy change for the oxidation of iron,



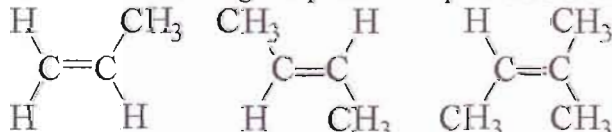
given the thermochemical equations below.



- a. +153.8 kJ
b. -304.1 kJ
c. -551.6 kJ
d. -608.2 kJ
e. -1216.4 kJ



7. For which of the following compounds is it possible for *cis* and *trans* isomers to exist?



(1)

(2)

(3)

↑
trans form

- a. 1 only
b. 2 only
c. 3 only
d. 1 and 2
e. 1, 2, and 3

8. How many electrons can be described by the following quantum numbers: $n = 5, \ell = 3, m_s = -1/2$?
- a. 3
 - b. 5 $s=0$
 - c. 7 $p=1$
 - d. 10 $d=2$
 - e. 14 $f=3$ ← 14 electrons possible but only 7 can have $m_s = -1/2$

9. Which of the following formulas is **not** correct?
- a. CaO ✓
 - b. Mg₃N₂ ✓
 - c. Na₂PO₄ Na ⇒ + PO₄ = 3- ✓
 - d. KNO₃ ✓
 - e. Al₂(CO₃)₃ ✓

10. Which of the following atoms is paramagnetic?
- a. Ba full s
 - b. Yb full f ← careful when counting this one. P-table is misleading
 - c. Hg full d
 - d. Bi not full, odd
 - e. Rn full p

11. Which one of the following molecules is polar?
- a. PF₅
 - b. I₃⁻
 - c. ClF₃
 - d. SO₃
 - e. XeF₄
-

12. Excited hydrogen atoms emit light in the infrared at 1.87 μm. What is the energy of a single photon with this wavelength?
- a. 1.24×10^{-39} J
 - b. 4.13×10^{-20} J
 - c. 1.60×10^{14} J
 - d. 6.24×10^{-15} J
 - e. 1.06×10^{-19} J

1.87 × 10⁻⁶ m

$$E = h\nu$$

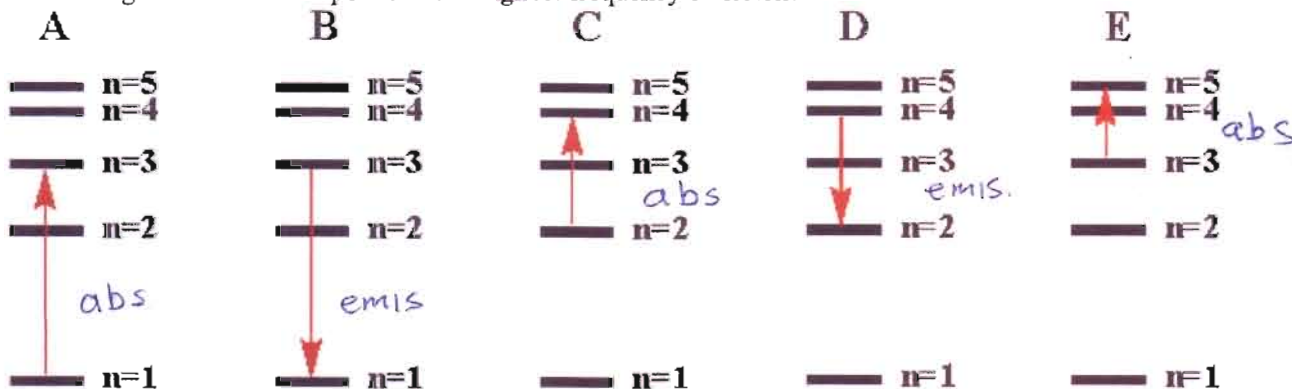
$$c = \lambda\nu$$

$$\frac{c}{\lambda} = \nu$$

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s})(2.985 \times 10^8 \frac{\text{m}}{\text{s}})}{1.87 \times 10^{-6} \text{ m}}$$

$$= 1.059 \times 10^{-19} \text{ J}$$

13. Which diagram below corresponds to the **highest** frequency emission?



- a. A
- b. B
- c. C
- d. D
- e. E

14. If the de Broglie wavelength of an electron is 15 nm, what is its velocity? The mass of an electron is 9.1×10^{-31} kg.

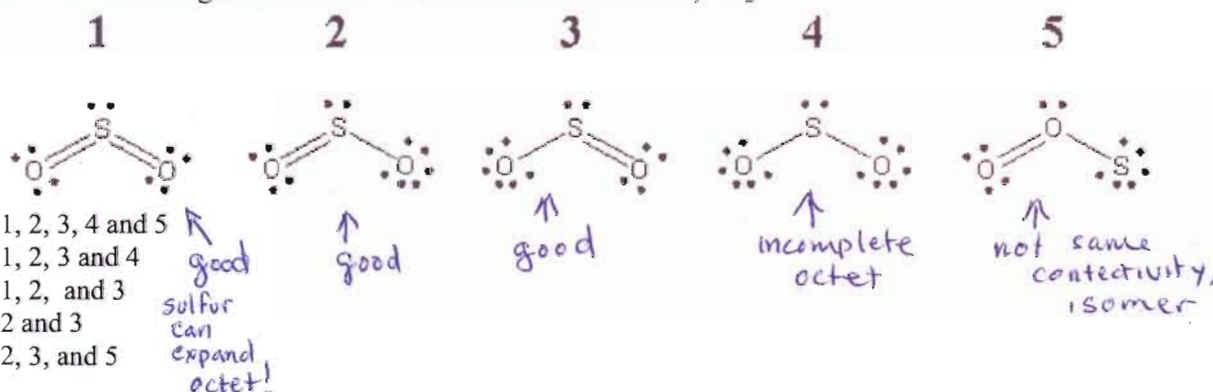
- a. 2.1×10^{-5} m/s
- b. 1.2×10^{-2} m/s
- c. 9.2×10^1 m/s
- d. 4.9×10^4 m/s
- e. 9.2×10^{10} m/s

$$\lambda = \frac{h}{mv}$$

$$v = \frac{h}{m\lambda} = \frac{6.626 \times 10^{-34} \text{ Js}}{9.1 \times 10^{-31} \text{ kg} \cdot 15 \times 10^{-9} \text{ m}}$$

$$= 48500 \text{ m/s}$$

15. Which of the following are resonance structures for sulfur dioxide, SO₂?



- a. 1, 2, 3, 4 and 5
- b. 1, 2, 3 and 4
- c. 1, 2, and 3
- d. 2 and 3
- e. 2, 3, and 5

16. Which three elements are likely to have similar chemical and physical properties?

- a. boron, silicon, and germanium
- b. sodium, magnesium, and aluminum
- c. magnesium, calcium, and strontium ← same group
- d. uranium, plutonium, and americium
- e. carbon, nitrogen, and oxygen

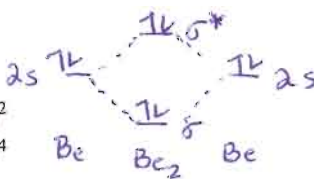
17. Which of the following statements is/are **CORRECT**?

- ~~1~~ Absorbance is directly proportional to the intensity of the incident light.
~~2~~ Absorbance is inversely proportional to the analyte concentration.
 ✓ 3. Absorbance is directly proportional to the path length of the light.

- a. 1 only
 b. 2 only
 c. 3 only
 d. 2 and 3
 e. 1, 2, and 3

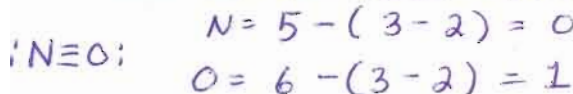
18. What is the molecular orbital configuration of Be_2 ?

- a. [core electrons]
 b. [core electrons] $(\sigma_{2s})^2$
 c. [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2$
 d. [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^2$
 e. [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4$



19. Consider the NO^+ . What is the formal charge on each atom? $FC = \text{val} - (\frac{1}{2}bc - \text{lep})$

- a. O atom = 0 and N atom = 0
 b. O atom = 0 and N atom = +1
 c. O atom = +1 and N atom = 0
 d. O atom = -1 and N atom = 0
 e. O atom = 0 and N atom = -1

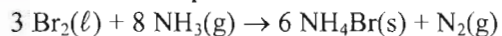


20. What is the net ionic equation for the reaction of aqueous sodium hydroxide and aqueous cobalt(III) chloride?

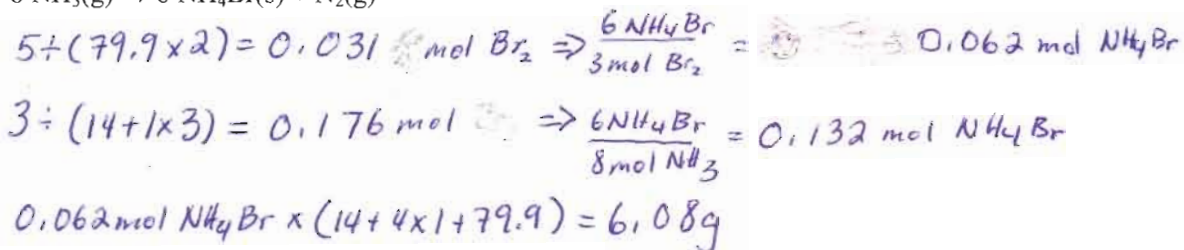
- a. $\text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{NaOH}(\text{s})$
 b. $\text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{NaCl}(\text{s})$
 c. $\text{Co}^{3+}(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{CoOH}^{2+}(\text{s})$
 d. $\text{Co}^{3+}(\text{aq}) + 3 \text{OH}^-(\text{aq}) \rightarrow \text{Co}(\text{OH})_3(\text{s})$
 e. $\text{Co}^{3+}(\text{aq}) + 3 \text{Cl}^-(\text{aq}) \rightarrow \text{CoCl}_3(\text{s})$



21. If 5.00 g Br₂ and 3.00 g NH₃ react according to the equation below, what is the **maximum** mass of ammonium bromide produced?



- a. 3.06 g
 b. 6.13 g
 c. 12.9 g
 d. 18.4 g
 e. 34.5 g

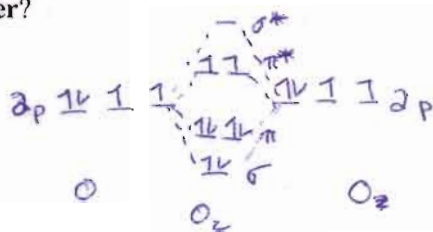


22. What is the balanced chemical equation for the complete combustion of methanol, CH₃OH?

- a. CH₃OH(ℓ) → CO(g) + 2 H₂(g)
 b. CH₃OH(ℓ) → CH₂(g) + H₂O(g)
 c. CH₃OH(ℓ) + O₂(g) → CO₂(g) + H₂O(g)
 d. 2 CH₃OH(ℓ) + 3 O₂(g) → 2 CO₂(g) + 4 H₂O(g)
 e. 2 CH₃OH(ℓ) + 4 O₂(g) → 2 CO₂(g) + 4 H₂O(g)

23. According to molecular orbital theory, which of the following lists ranks the oxygen species in terms of **increasing bond order**?

- a. O₂²⁺ < O₂²⁻ < O₂
 b. O₂²⁻ < O₂ < O₂²⁺
 c. O₂ < O₂²⁺ < O₂²⁻
 d. O₂ < O₂²⁻ < O₂²⁺
 e. O₂²⁺ < O₂ < O₂²⁻



Handwritten bond order calculations:

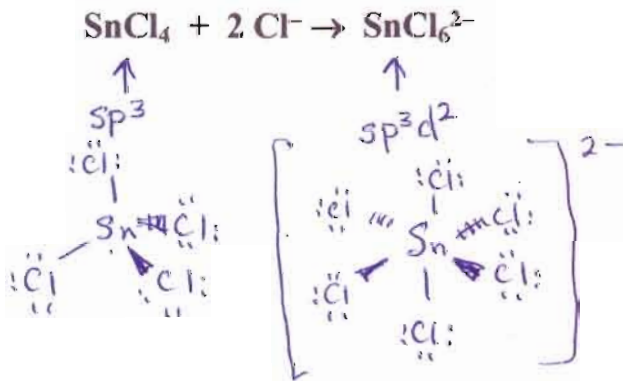
$$\text{B.O. O}_2 = 2$$

$$\text{O}_2^{2-} = 1$$

$$\text{O}_2^{2+} = 3$$

24. What change in hybridization of the tin atom occurs in the reaction below:

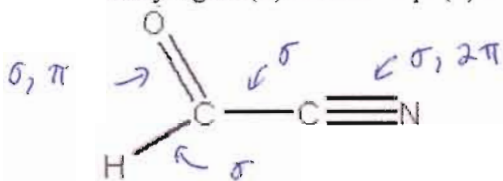
- a. sp³ to sp
 b. sp³ to sp³d²
 c. sp³ to sp³d
 d. sp to sp²
 e. sp to sp³



25. Which of the following statements is/are **CORRECT**?
- 1. A system is defined as an object or collection of objects being studied.
 - 2. Potential energy is the energy associated with motion.
 - 3. Increasing the thermal energy of a gas increases the motion of its atoms.
- a. 1 only
b. 2 only
c. 3 only
d. 1 and 3
e. 1, 2, and 3

26. What are the spectator ions in the reaction between aqueous nitric acid and ammonia?
- a. NO_3^- only**
- $$\text{HNO}_3(\text{aq}) + \text{NH}_3(\text{aq}) \rightarrow \text{NH}_4^+ \text{NO}_3^-(\text{aq})$$
- $$\text{H}^+(\text{aq}) + \text{NH}_3(\text{aq}) \rightarrow \text{NH}_4^+(\text{aq})$$
- b. H^+ only
c. H^+ and NH_4^+
d. NO_3^- and NH_4^+
e. H^+ , NO_3^- , and NH_4^+

27. How many sigma (σ) bonds and pi (π) bonds are in the following molecule?



- a. seven σ and three π
b. four σ and three π
c. two σ and five π
d. two σ and three π
e. four σ and two π
28. Which of the following molecules has the **smallest** bond angle between any two **hydrogen** atoms?
- b. H_2O**
-
- a. CH_4
c. BH_3
d. BeH_2
e. NH_3

29. _____ experimentally demonstrates that an electron has the properties of a wave and _____ experimentally demonstrates that light has the properties of a particle.
- a. electron diffraction, electron diffraction
b. the photoelectric effect, the photoelectric effect
c. the photoelectric effect, electron diffraction
d. electron diffraction, the photoelectric effect
e. mass spectroscopy, nuclear fission

30. Place the following ions in order from **smallest to largest** ionic radii: I^- , Sc^{2+} , Sc^{3+} , and Br^- .

- a. $Sc^{2+} < Sc^{3+} < Br^- < I^-$
 b. $I^- < Br^- < Sc^{2+} < Sc^{3+}$
 c. $Br^- < I^- < Sc^{3+} < Sc^{2+}$
 d. $Sc^{3+} < Sc^{2+} < Br^- < I^-$
 e. $Sc^{2+} < Sc^{3+} < I^- < Br^-$
- remove $e^- \rightarrow$ smaller
 gain $e^- \rightarrow$ bigger
 \downarrow P. table \rightarrow bigger*

31. Rank K, Ca, and Sc in order of increasing **second** ionization energy.

- a. $K < Ca < Sc$
 b. $Sc < Ca < K$
 c. $Ca < Sc < K$
 d. $Sc < K < Ca$
 e. $K < Sc < Ca$
- Ca want to lose two
 K wants to lose one, after that noble gas, very hard to remove
 Sc can lose two, no worries*

32. Which of the following diagrams represent p -orbitals?



- a. 1 only
 b. 1 and 2
 c. 1, 2 and 3
 d. 3 and 4
 e. 2 and 4

33. Liquid water can freeze to form ice. During this **change of state**:

- a. The temperature of the water decreases.
 b. The temperature of the water remains constant.
 c. The temperature of the water increases.
 d. The water gains energy.
 e. The water neither loses energy nor gains energy.

34. I start each class by saying...

- a. Well, it is on the money...
 b. Good news everybody!
 c. For homework...
 d. What a fine day for science!
 e. To recap, what we did last time...

Final Answer Section

MULTIPLE CHOICE

- | | | |
|------------|--------|-----------------------------------------------------------------------------|
| 1. ANS: B | PTS: 1 | TOP: 3.9 Oxidation-Reduction Reactions |
| 2. ANS: C | PTS: 1 | TOP: 5.2 Specific Heat Capacity: Heating and Cooling |
| 3. ANS: C | PTS: 1 | TOP: 1.5 Physical Properties |
| 4. ANS: E | PTS: 1 | TOP: 7.4 Electron Configurations of Ions |
| 5. ANS: D | PTS: 1 | TOP: 2.11 Hydrated Salts |
| 6. ANS: B | PTS: 1 | TOP: 5.7 Enthalpy Calculations |
| 7. ANS: B | PTS: 1 | TOP: 9.2 Valence Bond Theory |
| 8. ANS: C | PTS: 1 | TOP: 7.1 The Pauli Exclusion Principle |
| 9. ANS: C | PTS: 1 | TOP: 2.7 Ionic Compounds: Formulas, Names, and Properties |
| 10. ANS: D | PTS: 1 | TOP: 7.3 Electron Configurations of Atoms |
| 11. ANS: C | PTS: 1 | TOP: 8.8 Bond and Molecular Polarity |
| 12. ANS: E | PTS: 1 | TOP: 6.2 Planck, Einstein, Energy, and Photons |
| 13. ANS: B | PTS: 1 | TOP: 6.3 Atomic Line Spectra and Niels Bohr |
| 14. ANS: D | PTS: 1 | TOP: 6.4 Particle-Wave Duality: Prelude to Quantum Mechanics |
| 15. ANS: C | PTS: 1 | TOP: 8.4 Resonance |
| 16. ANS: C | PTS: 1 | TOP: 2.5 The Periodic Table |
| 17. ANS: C | PTS: 1 | TOP: 4.8 Spectrophotometry, Another method of Analysis |
| 18. ANS: C | PTS: 1 | TOP: 9.3 Molecular Orbital Theory |
| 19. ANS: C | PTS: 1 | TOP: 8.3 Atom Formal Charges in Covalent Molecules and Ions |
| 20. ANS: D | PTS: 1 | TOP: 3.6 Precipitation Reactions |
| 21. ANS: B | PTS: 1 | TOP: 4.2 Reactions in which One Reactant is Present in Limited Supply |
| 22. ANS: D | PTS: 1 | TOP: 3.2 Balancing Chemical Equations |
| 23. ANS: B | PTS: 1 | TOP: 9.3 Molecular Orbital Theory |
| 24. ANS: B | PTS: 1 | |
| 25. ANS: D | PTS: 1 | TOP: 5.1 Energy: Some Basic Principles |
| 26. ANS: A | PTS: 1 | TOP: 3.7 Acids and Bases |
| 27. ANS: B | PTS: 1 | TOP: 9.2 Valence Bond Theory |
| 28. ANS: B | PTS: 1 | TOP: 8.6 Molecular Shapes |
| 29. ANS: D | PTS: 1 | TOP: 6.5 The Modern View of Electronic Structure: Wave or Quantum Mechanics |
| 30. ANS: D | PTS: 1 | TOP: 7.5 Atomic Properties and Periodic Trends |
| 31. ANS: C | PTS: 1 | TOP: 7.5 Atomic Properties and Periodic Trends |
| 32. ANS: B | PTS: 1 | TOP: 6.6 The Shapes of Atomic Orbitals |
| 33. ANS: B | PTS: 1 | TOP: 5.3 Energy and Changes of State |
| 34. ANS: A | PTS: 1 | |