

CHEM _____ Lab Section Number: _____

Name (printed): _____

Signature: _____

This exam consists of 36 questions all of equal value for a total of 225 points. Make sure that your test has all of the pages. *Please read each problem carefully.* There are no intentionally misleading questions; each problem should be taken at its face value. Please mark your answers ***on the Scantron sheet*** provided to you ***and on the actual exam.***

You will be given a periodic table and an exam information sheet to use during the exam. You may remove it from the exam make it more accessible. You may also use the designated Casio fx-300ms-plus calculator or equivalent non-programmable non-graphing scientific calculator during the exam. Use the back pages of the test as scratch paper. You are not allowed to use any devices capable of accessing the internet, textbooks, notes, or homemade reference sheets during the exam.

You may leave if you finish the exam early. Give the exam and the information sheet to your TA and leave quietly without disturbing other students. Before leaving, check that all your answers have been properly entered on the Scantron sheet and the exam and that your name is written on every page of the exam and on the Scantron sheet.

All cell phones and electronic devices must be turned off and put away. Please remove all hats and caps. Place your books and all papers out of sight under your seat. If the TA believes that you might be looking at your neighbor's paper, you will be asked to move to a new location.

Exam scores will be posted on Blackboard as soon as the grading is complete. Your test will be returned to you in the first lab meeting of next week. If you have any questions regarding the grading of your exam, please notify your TA.

The time available for the exam is 120 minutes. **Good luck!**

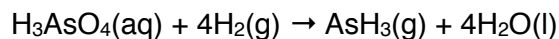
Name: _____ Lab Section #: _____

Please mark your answers on the scantron sheet using a #2 pencil and also mark your answers on the exam itself.

Mark Test From "A" on your scantron.

- A system that does no work but which transfers heat to the surroundings has:
 - $q < 0, \Delta E > 0$
 - $q > 0, \Delta E > 0$
 - $q > 0, \Delta E < 0$
 - $q < 0, \Delta E < 0$
 - $q < 0, \Delta E = 0$
- A system which undergoes an adiabatic change (i.e., $q = 0$) and does work on the surroundings has:
 - $w < 0, \Delta E < 0$
 - $w > 0, \Delta E > 0$
 - $w > 0, \Delta E < 0$
 - $w < 0, \Delta E > 0$
 - $w < 0, \Delta E = 0$
- A system delivers 225 J of heat to the surroundings while delivering 645 J of work. Calculate the change in the internal energy, ΔE , of the system.
 - 870. J
 420. J
 - 420. J
 870. J
 - 225 J
- A system absorbs 21.6 kJ of heat while performing 6.9 kJ of work on the surroundings. If the initial internal energy, E , is 61.2 kJ, what is the final value of E ?
 - 32.7 kJ
 - 46.5 kJ
 - 82.8 kJ
 - 89.7 kJ
 - 75.9 kJ

5. Calculate the $\Delta H^\circ_{\text{rxn}}$ for the following reaction. (See table for data).



Compound	$\text{AsH}_3(\text{g})$	$\text{H}_3\text{AsO}_4(\text{aq})$	$\text{H}_2\text{O}(\text{l})$	$\text{H}_2\text{O}(\text{g})$
$\Delta H_f^\circ(298)$	66.4 kJ/mol	-904.6 kJ/mol	-285.8 kJ/mol	-241.8 kJ/mol

- (a) -172.2 kJ
 (b) -1981.4 kJ
 (c) 3.8 kJ
 (d) 172.2 kJ
 (e) 685.2 kJ
6. Calculate $\Delta H_f^\circ(298)$ for $\text{CaCO}_3(\text{s})$ from the decomposition of calcium carbonate to calcium oxide and carbon dioxide. (See table for data).

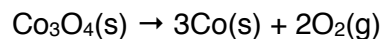


Compound	$\text{CaCO}_3(\text{s})$	$\text{CaO}(\text{s})$	$\text{CO}_2(\text{g})$
$\Delta H_f^\circ(298)$? kJ/mol	-635.1 kJ/mol	-393.5 kJ/mol

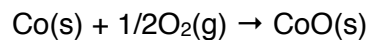
- (a) -2235.5 kJ
 (b) 178.3 kJ
 (c) -178.3 kJ
 (d) 2235.5 kJ
 (e) -1206.9 kJ
7. Which of the following equations represents the correct formation equation for methanol, $\text{CH}_3\text{OH}(\text{l})$?
- (a) $\text{C}(\text{graphite}) + 2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CH}_3\text{OH}(\text{l})$
 (b) $\text{C}(\text{graphite}) + 2\text{H}_2(\text{g}) + 1/2\text{O}_2(\text{g}) \rightarrow \text{CH}_3\text{OH}(\text{l})$
 (c) $\text{C}(\text{graphite}) + 2\text{H}_2(\text{g}) + \text{O}(\text{g}) \rightarrow \text{CH}_3\text{OH}(\text{l})$
 (d) $\text{C}(\text{graphite}) + 2\text{H}(\text{g}) + \text{O}(\text{g}) \rightarrow \text{CH}_3\text{OH}(\text{l})$
 (e) $\text{C}(\text{graphite}) + 4\text{H}(\text{g}) + \text{O}(\text{g}) \rightarrow 2\text{CH}_3\text{OH}(\text{l})$

8. Which of the following equations represents the correct formation equation for calcium sulfate dihydrate, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}(\text{s})$?
- (a) $\text{Ca}(\text{s}) + \text{S}_8(\text{s}) + 3\text{O}_2(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}(\text{s})$
 - (b) $\text{Ca}(\text{s}) + 1/8\text{S}_8(\text{s}) + 2\text{O}_2(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}(\text{s})$
 - (c) $\text{Ca}(\text{s}) + 1/8\text{S}_8(\text{s}) + 3\text{O}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}(\text{s})$
 - (d) $\text{Ca}(\text{s}) + 1/8\text{S}_8(\text{s}) + 3\text{O}_2(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}(\text{s})$
 - (e) $\text{Ca}(\text{s}) + 1/2\text{S}_8(\text{s}) + 3\text{O}_2(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}(\text{s})$
9. A piece of unknown substance weighs 44.7 g and requires 2110 J to increase its temperature from 23.2 °C to 89.6 °C. What is the specific heat of the substance?
- (a) 0.711 J/g°C
 - (b) 0.71 J/g°C
 - (c) 0.7 J/g°C
 - (d) 0.70 J/g°C
 - (e) 0.72J/g°C
10. A 0.500-g sample of KCl is added to 50.0 g of water in a calorimeter. If the temperature decreases by 1.05 °C, how much heat is involved in the dissolution of the KCl, assuming the specific heat capacity of the resulting solution is 4.18 J/g°C? Is the reaction exothermic or endothermic?
- (a) 222 J, Endothermic
 - (b) -222 J, Exothermic
 - (c) -222 J, Endothermic
 - (d) 222 J, Exothermic
 - (e) No heat is produced
11. The addition of 3.15 g of $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$ to a solution of 1.52 g of NH_4SCN in 100. g of water in a calorimeter caused the temperature to fall by 3.1 °C. Assuming the specific heat of the solution and products is 4.20 J/g°C, calculate the amount of heat involved in the dissolution. Is the reaction exothermic or endothermic?
- (a) 1.4 kJ, Exothermic
 - (b) 1.4 kJ, Endothermic
 - (c) -1.4 kJ Endothermic
 - (d) -1.4 kJ, Exothermic
 - (e) No heat is produced
12. If a reaction produces 1.506 kJ of heat, which is trapped in 30.0 g of water initially at 26.5 °C in a calorimeter, what is the final temperature of the water?
- (a) 12.0 °C
 - (b) -12.0 °C
 - (c) 26.5 °C
 - (d) -38.5 °C
 - (e) 38.5 °C

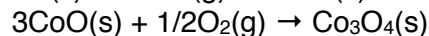
13. Calculate $\Delta H_f^\circ(298)$ for the following reaction from the information given:



$$\Delta H_f^\circ(298) = ?$$



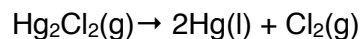
$$\Delta H_f^\circ(298) = -237.9 \text{ kJ}$$



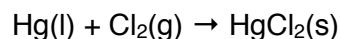
$$\Delta H_f^\circ(298) = -177.5 \text{ kJ}$$

- (a) -891.2 kJ
- (b) 891.2 kJ
- (c) 415.4 kJ
- (d) -415.4 kJ
- (e) 60.4 kJ

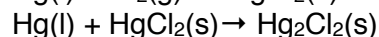
14. Calculate ΔH_{rxn} for the following reaction from the information given:



$$\Delta H_{\text{rxn}} = ?$$



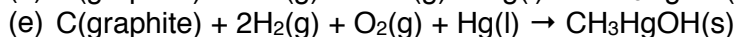
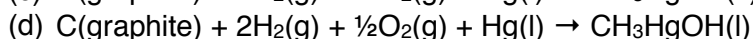
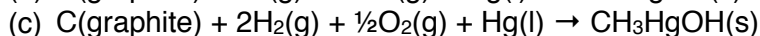
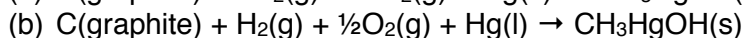
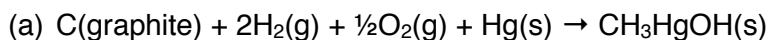
$$\Delta H = -224 \text{ kJ}$$



$$\Delta H = -41.2 \text{ kJ}$$

- (a) -265 kJ
- (b) 182.8 kJ
- (c) -182.8 kJ
- (d) 265 kJ
- (e) 530. kJ

15. Which of the following equations represents the correct formation equation for $\text{CH}_3\text{HgOH}(\text{s})$?



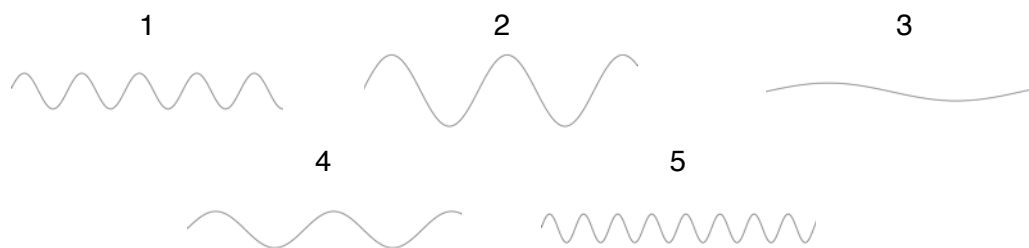
16. How much will the temperature of a cup (180 g) of coffee at 95 °C be reduced when a 45 g silver spoon (specific heat 0.24 J/g °C) at 25 °C is placed in the coffee and the two are allowed to reach the same temperature? Assume that the coffee has the same density and specific heat capacity as water.

- (a) 25 °C
- (b) 95.0 °C
- (c) 90. °C
- (d) 95 °C
- (e) 94 °C

17. Of the symbols below, which is used to express heat capacity?

- (a) ν
- (b) λ
- (c) P
- (d) c
- (e) C

Below are the graphical representations of five (numbered) waves. Use those images to answer the following two questions.



18. Which of the waves in the figure above has the shortest wavelength?

- (a) Wave 1
- (b) Wave 2
- (c) Wave 3
- (d) Wave 4
- (e) Wave 5

19. Which of the waves in the figure above has the lowest energy?

- (a) Wave 1
- (b) Wave 2
- (c) Wave 3
- (d) Wave 4
- (e) Wave 5

20. An FM radio station found at 103.1 on the FM dial broadcasts at a frequency of 103.1 MHz. What is the wavelength of these radio waves in meters?

- (a) 2.910 m
- (b) 2.910 km
- (c) 29.1 m
- (d) 2.91 m
- (e) 0.29100 km

21. A bright violet line occurs at 435.8 nm in the emission spectrum of mercury vapor. What amount of energy, in joules, must be released by an electron in a mercury atom to produce a photon of this light?
- (a) 45.61×10^{-19} kJ
 - (b) 4.561 kJ
 - (c) 4.561 J
 - (d) 4.561×10^{-19} J
 - (e) 4.56×10^{-19} J
22. One of the radiographic devices used in a dentist's office emits an X-ray of wavelength 2.090×10^{-11} m. What is the frequency of this X-ray radiation?
- (a) 1.435 s^{-1}
 - (b) 1.435 kHz
 - (c) 1.435 MHz
 - (d) 1.435×10^{19} Hz
 - (e) 1435 s^{-1}
23. What will be the energy change of an electron on a Li^{2+} atom when the electron moves from the the $n=3$ to the $n=6$ level? Would this be considered absorption or emission?
- (a) 1.64×10^{-18} J, absorption
 - (b) -1.64×10^{-18} J, emission
 - (c) -1.64×10^{-18} J, absorption
 - (d) 1.64×10^{-18} J, emission
 - (e) 2.18×10^{-18} J, absorption
24. What is the energy of a hydrogen electron in an orbit with $n = 3$?
- (a) -7.85×10^{-19} J
 - (b) -8.72×10^{-20} J
 - (c) -2.42×10^{-19} J
 - (d) -4.36×10^{-19} J
 - (e) -2.18×10^{-18} J
25. What will be the energy change of a hydrogen electron when it moves from the the $n=6$ to the $n=4$ level? Would this be considered absorption or emission?
- (a) 2.18×10^{-18} J, absorption
 - (b) 7.57×10^{-20} J, absorption
 - (c) -7.57×10^{-20} J, absorption
 - (d) 7.57×10^{-20} J, emission
 - (e) -7.57×10^{-20} J, emission

26. What type of electromagnetic radiation has a wavelength of ten meters.

- (a) Infrared (IR)
- (b) Ultraviolet (UV)
- (c) X-ray
- (d) Radio Frequency (RF)
- (e) Visible

27. Write the complete electron configuration for the Zn^{2+} ion.

- (a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
- (b) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$
- (c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$
- (d) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$
- (e) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

28. Which of the following is a correct set of quantum numbers for a 3d orbital?

- (a) $n = 3, l = 0, m_l = -1$
- (b) $n = 3, l = 1, m_l = +3$
- (c) $n = 3, l = 2, m_l = 3$
- (d) $n = 3, l = 3, m_l = +2$
- (e) $n = 3, l = 2, m_l = -2$

29. Which one of the following sets of quantum numbers can correctly represent a 3p orbital?

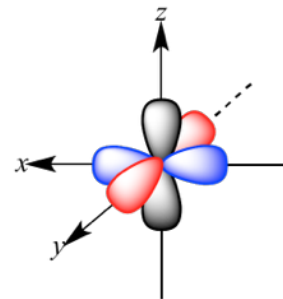
- (a) $n = 3, l = 1, m_l = 2$
- (b) $n = 1, l = 3, m_l = 3$
- (c) $n = 3, l = 2, m_l = 1$
- (d) $n = 3, l = 1, m_l = -1$
- (e) $n = 3, l = 0, m_l = 1$

30. The de Broglie equation predicts that the wavelength (in m) of a 151.5 g baseball moving at a velocity of 25.0 m/s is

- (a) 1.75×10^{-34} m
- (b) 3.96×10^{-31} m
- (c) 1.749×10^{-14} m
- (d) 3.5×10^{-34} m
- (e) $>10^{10}$ m

31. Which of the atomic orbitals listed below correctly identifies the type of orbital depicted in the image to the right? What is the correct l quantum number for this orbital?

- (a) $2s, l = 0$
- (b) $2p, l = 0$
- (c) $2p, l = 1$
- (d) $2p, l = 2$
- (e) $2d, l = 3$



32. List the following ions in order of increasing radius: Te^{2-} , Br^- , Li^+ , Na^+ .

- (a) $\text{Te}^{2-} < \text{Br}^- < \text{Li}^+ < \text{Na}^+$
- (b) $\text{Na}^{2+} < \text{Li}^+ < \text{Br}^- < \text{Te}^{2-}$
- (c) $\text{Li}^+ < \text{Na}^+ < \text{Br}^- < \text{Te}^{2-}$
- (d) $\text{Br}^- < \text{Te}^{2-} < \text{Li}^+ < \text{Na}^+$
- (e) $\text{Br}^- < \text{Te}^{2-} < \text{Na}^+ < \text{Li}^+$

33. Based on their position in the periodic table, predict which has the smallest first ionization potential?

- (a) Li
- (b) Cs
- (c) N
- (d) F
- (e) I

34. Based on their position in the periodic table, predict which has the largest atomic radius?

- (a) I
- (b) F
- (c) N
- (d) Rb
- (e) Li

35. Write the complete electron configuration for the Ca^{2+} ion.

- (a) $1s^2 2s^2 2p^6$
- (b) $1s^2 2s^2 2p^6 3s^2$
- (c) $1s^2 2s^2 2p^6 3s^1$
- (d) $1s^2 2s^2 2p^6 3s^2 4s^2 3p^6$
- (e) $1s^2 2s^2 2p^6 3s^2 3p^6$

36. How many valence electrons does Germanium (Ge) have?

- (a) 0
- (b) 2
- (c) 4
- (d) 10
- (e) 14

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