

Name: _____
Last Name First Name

Perm # _____

There are a total of nine pages (42 questions) on the exam. **You must show your work on the exam.** We can evaluate your exam only if you have shown work.

SCANTRON FORM:Completely fill bubbles 

1) Write your name

Completely fill answers 2) Bubble in **FORM B**3) Bubble in your **PERM** number (7 digits only, no extra numbers)**INFORMATION PAGE:** Remove the information page. No other notes or books are allowed.**INSTRUCTIONS: Turn in your Exam and Scantron form.** No hats/hoods allowed. No sharing of calculators. Cell Phones, iPods, headsets, and any other electronic devices must be turned off and put away.**ANSWERS are at the end of the exam**

- (4 pts) Which of the following elements has the highest first ionization energy?
 - Li
 - Si
 - C
 - B
 - Al
- (4 pts) For which of the following transitions does the light emitted have the longest wavelength?
 - $n = 6$ to $n = 4$
 - $n = 4$ to $n = 6$
 - $n = 6$ to $n = 3$
 - $n = 3$ to $n = 6$
 - $n = 6$ to $n = 5$
- (4 pts) How many electrons can be described by the quantum numbers $n = 4$, $m_l = -1$?
 - 8
 - 2
 - 4
 - 6
 - 10

4. (4 pts) How many electrons in an atom can have the quantum numbers $n = 3, l = 2$?
- 10
 - 2
 - 6
 - 8
 - 32
5. (4 pts) Which of the following is *NOT* determined by the principal quantum number, n , of the electron in a hydrogen atom?
- the energy of the electron
 - the minimum wavelength of the light needed to remove the electron from the atom.
 - the size of the corresponding atomic orbital(s)
 - the shape of the corresponding atomic orbital(s)
 - All of the above are determined by n .
6. (4 pts) Which combination of quantum numbers is *NOT* allowed? Combinations are listed as follows:
- | | n | l | m_l | m_s |
|----|------------------|-----|-------|-------|
| a) | 3 | 1 | +1 | +1/2 |
| b) | 5 | 3 | -1 | -1/2 |
| c) | 1 | 1 | 0 | -1/2 |
| d) | 3 | 0 | 0 | -1/2 |
| e) | All are allowed. | | | |
7. (4 pts) Which of the following is an excited state electron configuration ?
- $[\text{Ar}]4s^23d^3$
 - $1s^22s^22p^4$
 - $1s^22s^22p^63s^23p^64s^1$
 - $[\text{Ar}]4s^23d^64p^1$
 - $[\text{Ar}] 4s^23d^4$
8. (3 pts) Which of the following atoms has two unpaired electrons?
- Fe
 - Cl
 - Al
 - V
 - Ni

9. (4 pts) Phosphorus is the central atom in PO_3^{3-} . Determine the number of lone pairs on the phosphorus atom in the Lewis structure for PO_3^{3-} .

- a) 0
- b) 1
- c) 2
- d) 3
- e) 4

10. (4 pts) Determine the total number of lone pairs in the Lewis structure for N_2H_4 .

- a) 0
- b) 2
- c) 4
- d) 8
- e) 10

11. (4 pts) How many bonds are there in the Lewis structure for NO_3^- ? Nitrogen is the central atom.

- a) 3
- b) 4
- c) 5
- d) 6
- e) 2

12. (4 pts) How many acceptable and equivalent resonance structures can be drawn for NO_3^- ? Nitrogen is the central atom.

- a) 0
- b) 1
- c) 2
- d) 3
- e) 4

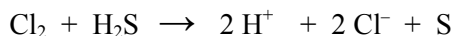
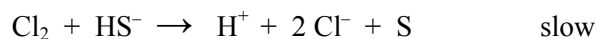
13. (5 pts) Consider the reaction the following reaction. $2\text{NO}(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{N}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$

$[\text{NO}]_0$ (M)	$[\text{H}_2]_0$ (M)	Initial Rate (M/s)
0.16	0.32	0.0200
0.16	0.48	0.0300
0.32	0.32	0.0800

What is the numerical value of the rate constant?

- a) 2.4
- b) 7.6
- c) 0.39
- d) 1.2
- e) 0.13

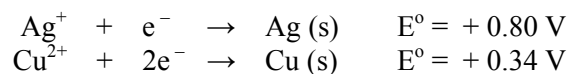
14. (5 pts) Consider the following mechanism.



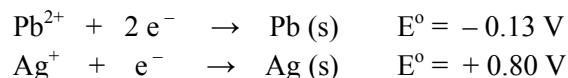
In the rate law for the mechanism given above, what is the order with respect to H^+ ?

- a) -1
 - b) -2
 - c) 1
 - d) 2
 - e) 1/2
15. (5 pts) Raw milk sours in 4.0 hours at 28°C but takes 48 hours to sour in a refrigerator at 5°C. Calculate the activation energy for the souring of milk.
- a) 8.87 kJ
 - b) 85.6 kJ
 - c) 75.2 kJ
 - d) 4.00 kJ
 - e) 12.0 kJ
16. (5 pts) The decomposition of N_2O to produce N_2 and O_2 is a first order reaction. At 730 °C the half-life of the reaction is 3.58×10^3 minutes. If the initial pressure of N_2O is 2.10 atm at 730 °C, calculate the total gas pressure after one half-life. Assume that the volume remains constant.
- a) 4.20 atm
 - b) 2.90 atm
 - c) 2.63 atm
 - d) 3.15 atm
 - e) None of these

Questions 17 – 18. A galvanic cell is constructed with a strip of copper placed in a 1 M solution of copper nitrate, and a strip of silver placed in a 1 M solution of silver nitrate. The two metal strips are connected by a wire, and a salt bridge connects the solutions. The standard reduction potentials at 25 °C are:



17. (5 pts) In the cell described above, at standard conditions, what species are produced at each electrode?
- Ag is produced at the anode, and Cu^{2+} is produced at the cathode.
 - Ag is produced at the anode, and Cu is produced at the cathode.
 - Ag is produced at the cathode, and Cu^{2+} is produced at the anode.
 - Cu is produced at the cathode, and Ag^+ is produced at the anode.
 - Cu is produced at the anode, and Ag^+ is produced at the cathode.
18. (5 pts) In the cell described above, calculate the cell potential at 25 °C when $[\text{Cu}^{2+}] = 0.0034 \text{ M}$ and $[\text{Ag}^+] = 0.34 \text{ M}$.
- 0.51 V
 - 0.59 V
 - 0.41 V
 - 0.52 V
 - 0.40 V
19. (5 pts) A galvanic cell is constructed with a silver electrode in a AgNO_3 (aq) solution and the lead electrode in a $\text{Pb(NO}_3)_2$ (aq) solution at 25 °C. The standard reduction potentials are:



Initially $[\text{Pb}^{2+}] = 5.0 \text{ M}$ and $[\text{Cu}^{2+}] = 4.0 \text{ M}$. When sulfuric acid is added to the $\text{Pb(NO}_3)_2$ (aq) solution, a PbSO_4 (s) precipitate is formed causing the $[\text{Pb}^{2+}]$ to change by 2.0 M. Calculate the cell potential after this change has occurred.

- 0.94 V
- 0.95 V
- 0.91 V
- 0.92 V
- 0.93 V

20. (5 pts) In a common car battery, six identical cells each carry out the following reaction:



For such a cell, E° is 2.04 V. Calculate ΔG° at 25°C.

- a) -0.121 kJ
- b) -787 kJ
- c) -98 kJ
- d) -197 kJ
- e) -394 kJ

21. (5 pts) For the combustion of acetylene gas, $\text{C}_2\text{H}_2 \text{ (g)}$, the standard enthalpy change, $\Delta H^\circ = -1299 \text{ kJ/mol}$ at 298 K. Given the following enthalpies of formation, calculate ΔH_f° for $\text{C}_2\text{H}_2 \text{ (g)}$.

ΔH_f° (kJ/mol)

$\text{CO}_2 \text{ (g)}$	- 393
$\text{H}_2\text{O (l)}$	- 286

- a) + 227 kJ/mol
- b) + 625 kJ/mol
- c) + 423 kJ/mol
- d) - 625 kJ/mol
- e) + 454. kJ/mol

22. (5 pts) A gas absorbs 47.5 kJ of heat and then performs 3.2 kJ of work. What is the change in internal energy of the gas?

- a) - 50.7kJ
- b) +44.3 kJ
- c) -44.3 kJ
- d) +50.7 kJ
- e) +14.8 kJ

23. (3 pts) Which of the following atoms has the smallest radius?

- a) N b) S c) Mg d) O e) P

24. (3 pts) Which of the following elements is the most electronegative?

- a) N b) Al c) B d) C e) P

25. (3 pts) Choose the molecule with the strongest bond.
- a) HI b) HBr c) HCl d) HF
26. (3 pts) Which of the following has the largest radius?
- a) S^{2-} b) Cl^- c) Ar d) K^+ e) Ca^{2+}
27. (3 pts) Which of the following bonds is the least polar?
- a) H – Cl b) C – H c) O – H d) N – H e) H – F

Questions 28 – 31. (3 pts each) For each of the following processes indicate if ΔS is negative or positive?

28. Grind a large KCl crystal into powder a) $\Delta S < 0$ b) $\Delta S > 0$
29. Raising the temperature of 100 g of Cu (s) from 275 K to 295 K a) $\Delta S < 0$ b) $\Delta S > 0$
30. Compressing 1 mol of Ne at constant temperature from 0.5 atm to 1.5 atm a) $\Delta S < 0$ b) $\Delta S > 0$
31. Evaporation of 1 mol of $CCl_4 (l)$ a) $\Delta S < 0$ b) $\Delta S > 0$

32. (4 pts) Which of the following is always positive when a spontaneous process occurs?

- a) ΔS_{system}
b) $\Delta S_{\text{universe}}$
c) $\Delta S_{\text{surroundings}}$
d) ΔG_{system}
e) None of the above.

33. (5 pts) Consider the process in which 1.2 mol of an ideal gas at 304 K is compressed isothermally and reversibly from 1.8 L to 0.50 L. Determine ΔS for this process.

- a) +13 J/K
b) -3.9 kJ/K
c) -11 J/K
d) -13 J/K
e) -6 J/K

34. (5 pts) Which statement is true of a process in which 1 mol of a gas expands from state A to state B?

- a) When the gas expands from state A to state B, the surroundings are doing work on the system.
- b) The amount of work done in the process must be the same, regardless of the path.
- c) The change in internal energy depends on the final volume of the gas.
- d) The final volume of the gas will depend on the path taken.
- e) The amount of heat released in the process will depend on the path taken.

Questions 35 –37. (4 pts each) Indicate true or false for each of the following statements.

35. Spontaneous reactions must have a positive ΔS° for the reaction.

- a) True
- b) False

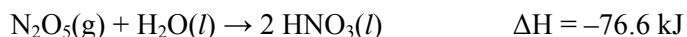
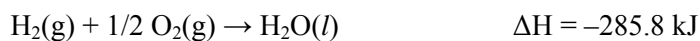
36. When ΔG is less than zero for a chemical reaction, the reaction must be exothermic.

- a) True
- b) False

37. For a spontaneous reaction, if $\Delta S^\circ < 0$ then the reaction must be exothermic.

- a) True
- b) False

38. (5 pts) You are given the following data.



Calculate ΔH for the following reaction: $2 \text{N}_2(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 2 \text{N}_2\text{O}_5(\text{g})$

- a) 105 kJ
- b) -105 kJ
- c) 314 kJ
- d) -28.4 kJ
- e) 28.4 kJ

39. (5 pts) For substance X, the heat of vaporization is 55.4 kJ/mol at its normal boiling point, 423 °C. Calculate the value of ΔS when 2 moles of X evaporate at 1 atm and 423 °C.

- a) 159 J/K
- b) 262 J/K
- c) -159 J/K
- d) 79.6 J/K
- e) -262 J/K

Questions 40 and 41. One mole of an ideal gas with a volume of 1.9 L and a pressure of 5.5 atm is allowed to expand isothermally into an evacuated bulb to give it a total volume of 4.1 L.

40. (5 pts) Calculate the work, w , for this process.

- a) 223J
- b) -223 J
- c) 0
- d) 1226 J
- e) -1226 J

41. (5 pts) Calculate q_{rev} for this process.

- a) 0
- b) 814 J
- c) -814 J
- d) 1906 J
- e) -1906 J

42. (5 pts) The molar entropy of helium gas at 25 °C and 1.00 atm is $126.1 \text{ J K}^{-1} \text{ mol}^{-1}$. Assuming ideal behavior, calculate the entropy of 0.261 mole of helium gas at 25 °C and a volume of 5.25 L.

- a) 32.5 J/K
- b) 125.7 J/K
- c) 122.7 J/K
- d) 29.6 J/K
- e) none of these

ANSWERS: 1. c 2. e 3. d 4. a 5. d 6. c 7. d 8. e 9. b 10. b 11. b 12. d 13. a
14. a 15. c 16. c 17. c 18. a 19. b 20. e 21. a 22. b 23. d 24. a 25. d 26. a
27. b 28. b 29. b 30. a 31. b 32. b 33. d 34. e 35. b 36. b 37. a 38. e 39. a
40. c 41. b 42. a The point value of each question is indicated at the start of each question.

Partial Credit (2 pts each): 14. c 19. c 42. b 42. c 42. d

Note: Question 30, I changed the pressures from 0.5 to 1.5 atm. Compressing a gas at constant T will increase the pressure; for this process $\Delta S < 0$. I incorrectly had the pressure decrease from 1.5 to 0.5 atm. Either answer, a or b, was given full credit.