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This test is closed note/book. One 8.5 x 11 handwritten crib sheet (one sided) is permitted.

Use a #2 pencil. Calculators are permitted. Computers, PDAs, and other electronic devices with a keyboard are not. Please turn off your cell phone. Cell phones may not be used as calculators.

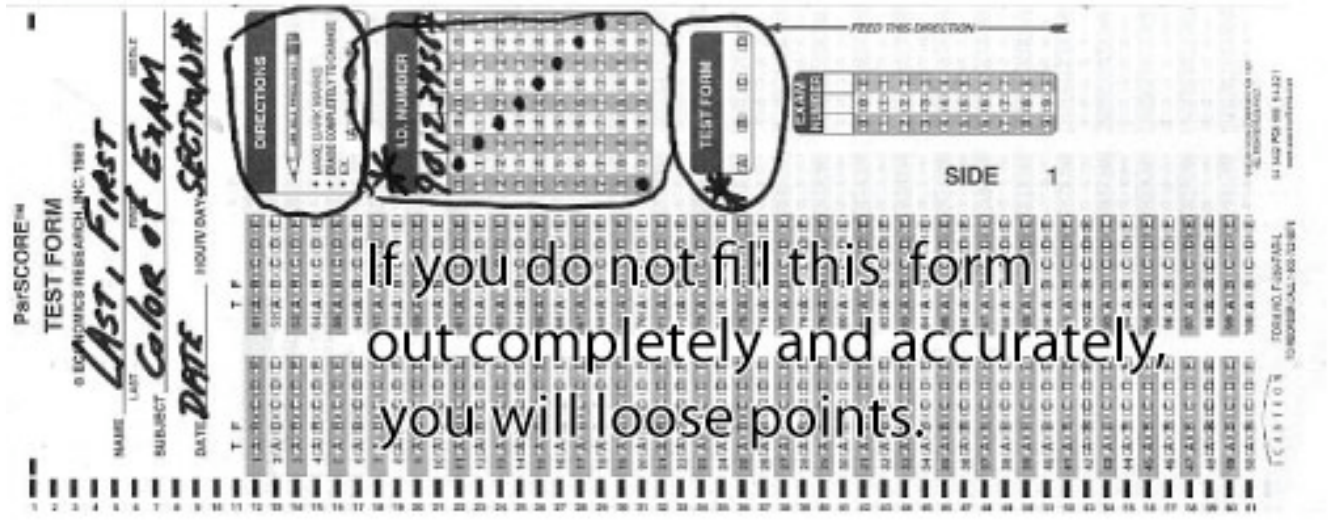
Write your name on this exam. Complete the Scantron card as shown below. You must bubble in your ID number, write in your section number and identify your Test Form (see top of this page). Scantron errors and omissions are punishable by point deductions.

When you take the exam, bubble in the scanton form *and* circle your answers on this exam. You must hand in both the scantron and the exam.

A total of 50 minutes is allotted for the exam. There are 20 questions. Each is worth five points. Answer every question. There is no penalty for guessing.

Circle Your Section Number

A1	M 2-3PM	CoC 52
A2	M 2-3PM	CoC 53
A3	M 2-3PM	MSE 1201A
A4	M 2-3PM	MSE 1222
A5	M 2-3PM	MSE 1224
B1	M 3-4PM	CoC 52
B2	M 3-4PM	CoC 53
B3	M 3-4PM	MSE 12101A
B4	M 3-4PM	MSE 1222
B5	M 3-4PM	MSE 1224



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1. You are given a solution of the weak base Novocain, Nvc. The pH of the solution is 11.0. You add the chloride salt of the conjugate acid of Novocain, $NvcH^+Cl^-$. Which statement is true?

A) The pH and the pOH both increase.
B) The pH and the pOH both decrease.
C) The pH and the pOH remain unchanged.
D) The pH increases and pOH decreases.
E) The pH decreases and the pOH increases.

Answer: E
Chapter 7

2. Calculate $[H^+]$ in a solution that is 0.24 *M* in NaF and 0.60 *M* in HF ($K_a = 7.2 \times 10^{-4}$).

A) 0.60 *M*
B) 2.9×10^{-4} *M*
C) 1.8×10^{-3} *M*
D) 2.1×10^{-2} *M*
E) 1.0×10^{-4} *M*

Answer: C

	HF	H^+	F^-
I	0.6	0	0.24
C	-x	x	x
E	0.60-x	x	0.24+x

$K_a = x(0.24+x)/(0.6-x) = x(0.24)/0.6$ (approx)
$(7.2 \times 10^{-4})0.6/(0.24) = 1.8 \times 10^{-3}$
Chapter 7

3. For ammonia (NH_3), K_b is 1.8×10^{-5}. The buffering capacity of a 1 M solution of NH_4Cl is at a maximum at a pH of

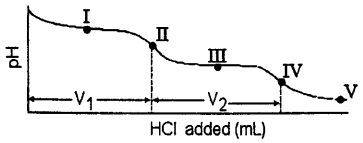
A) 4.7
B) 7.2
C) 12.2
D) 9.3
E) none of these

Answer: D
$pK_b = -4.75$
$pK_a = 9.3$, buffering capacity is max when pH = pK_a
Chapter 8

4. Consider the following information about diprotic ascorbic acid (H_2As).

	K_a	pK_a
$H_2As \rightleftharpoons H^+ + HAs^-$	7.9×10^{-5}	4.10
$HAs^- \rightleftharpoons H^+ + As^{2-}$	1.6×10^{-12}	11.8

The curve for titration of disodium ascorbate (Na_2As) with HCl is shown below:



What major species is (are) present at point III of the titration curve (note that the titration starts with essentially 100% As^{2-})?

A) As^{2-} and HAs^-

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B) HAs^- only
C) HAs^- and H_2As
D) H_2As only
E) H_2As and H^+
Answer: C
Chapter 8

5. Refering to the disodium ascorbate titration above: which of the following is a major species present at point IV?
A) H_2As
B) HAs^-
C) As^{2-}
D) H^+
E) none of these
Answer: A
Chapter 8

Print Name_____ Signature _____

6. A gas releases 3.8 J of heat to the surroundings and performs 13.7 J of work. What is the change in energy of the gas?
A) –17.6 J
B) 17.6 J
C) –9.9 J
D) 9.9 J
E) 3.8 J
Answer: A
ΔE = q + w = -3.8 J + (-13.7 J) = -17.6 J
Chapter 9

6. (question not used) Calculate Δ*E* for a system that releases 35 J of heat to the surroundings while 54 J of work is done on it.
A) –89 J
B) –19 J
C) 19 J
D) 89 J
E) 35 J
Answer: C
ΔE = q + w = -35 J + 54 J = +19 J
Chapter 9

7. Which of the following statements is false?
A) In going from a particular set of reactants to a particular set of products, the change in enthalpy is the same, whether the reaction takes place in a series of steps or in a single step.
B) The entropy of the universe increases for any spontaneous process.
C) The energy of the universe is conserved.
D) A system will always proceed spontaneously to the arrangement with the lowest enthalpy.
E) Energy cannot be created or destroyed.
Answer: D

7 (question not used). Calculate the work for the expansion of an ideal gas from 3.0 to 6.0 L against an external pressure of 1.6 atm at constant temperature.
A) 4.8 L•atm
B) –4.8 L•atm
C) 0.0 L•atm
D) 5.6 L•atm
E) –1.9 L•atm
Answer: B
w = -PΔV = -1.6 atm (6.0 L - 3.0 L) = -4.8 L-atm
Chapter 9

7 (question not used). Calculate the work for the compression of an ideal gas from 6.0 to 3.0 L against an external pressure of 1.6 atm at constant temperature.
A) 4.8 L•atm
B) –4.8 L•atm
C) 0.0 L•atm
D) 5.6 L•atm
E) –1.9 L•atm
Answer: A
w = -PΔV = -1.6 atm (3.0 L - 6.0 L) = 4.8 L-atm
Chapter 9

Consider the following process carried out on 1.0 mol of a monatomic ideal gas at constant pressure:

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Start: (3.00 atm, 20.0 L)
End: (3.00 atm, 50.0 L).

8. Calculate the work, *w*.
A) -90 L•atm
B) 90 L•atm
C) -30 L•atm
D) 30 L•atm
E) 0 L•atm
Answer: A
$w = -P\Delta V = -3 \text{ atm } (50 \text{ L} - 20 \text{ L}) = -90 \text{ L-atm}$
Chapter 9

9. Calculate the heat, *q*.
A) 226 L•atm
B) -226 L•atm
C) 135 L•atm
D) -135 L•atm
E) none of these
Answer: A
$T(A) = PV/nR = (3 \text{ atm})(20 \text{ L})/[(1.0 \text{ mol})(0.082 \text{ L-atm mol}^{-1} \text{ mol}^{-1} \text{ K}^{-1})] = 731 \text{ K}$
$T(B) = PV/nR = (3 \text{ atm})(50 \text{ L})/[(1.0 \text{ mol})(0.082 \text{ L-atm mol}^{-1} \text{ K}^{-1})] = 1830 \text{ K}$
$\Delta T = 1099 \text{ K}$
$q = nC_p\Delta T = (1 \text{ mol})(5/2 \text{ R J mol}^{-1} \text{ K}^{-1})(101 \text{ J/L-atm})^{-1}(1099 \text{ K})$
$= (5/2 \times 8.31)\ 1099/101 = 226 \text{ L-atm}$

10. The same amount of heat is added to two metal blocks of equal number of moles but made of different metals. Which undergoes the smaller change in temperature?
A) The metal with the higher heat capacity.
B) The metal with the lower heat capacity.
C) Both undergo the same change in temperature.
D) To determine this, you need to know the initial temperatures of the metals.
E) To determine this, you need to know which metals you are talking about.
Answer: A
Chapter 9

11. As a warm brick (the system) spontaneously cools in a cold pool of water (the surroundings), the entropy of the brick (S_{system})
A) increases
B) decreases
C) does not change
D) changes in a way that cannot be predicted
E) all of the above
Answer: B
Chapter 10

Print Name_____ Signature _____

12. As the warm brick (the system) spontaneously cools in the cold pool of water (the surroundings), the entropy of the surroundings ($S_{surroundings}$)
A) increases
B) decreases
C) does not change
D) changes in a way that cannot be predicted
E) all of the above
Chapter 10
Answer: A

13. As the warm brick (the system) spontaneously cools in the cold pool of water (the surroundings),
A) $|\Delta S_{system}| > |\Delta S_{surroundings}|$
B) $|\Delta S_{system}| < |\Delta S_{surroundings}|$
C) $|\Delta S_{system}| = |\Delta S_{surroundings}|$
D) the relationship of $|\Delta S_{system}|$ and $|\Delta S_{surroundings}|$ cannot be predicted
E) none of the above
Chapter 10
Answer: B

14. Consider the gas phase reaction

$$NO + (1/2)O_2 \rightleftharpoons NO_2$$

$\Delta H° = -57.0$ kJ/mol

What is $\Delta H°$ for the following reaction:

$$2NO + O_2 \rightleftharpoons 2NO_2$$

A) 57.0 kJ
B) –114 kJ
C) 114 kJ
D) –28.5 kJ
E) 778 kJ
Answer: B
Chapter 9

15. In a reaction where a diatomic molecule (for example O_2) spontaneously forms from its atoms at standard temperature and pressure, what are the signs of ΔH, ΔS, and ΔG, respectively?
A) – – –
B) + + +
C) + – –
D) – + +
E) – – +
Answer: A
Chapter 10

16. Consider the spontaneous freezing of liquid water at –10°C. For this process what are the signs for ΔH, ΔS, and ΔG, respectively?
A) + – 0
B) – + 0
C) – + –
D) + – –
E) – – –
Answer: E
Chapter 10

Print Name_____ Signature _____

17. Which one of the following processes has $\Delta H < 0$?
A) freezing of liquid Hg
B) combustion of cellulose
C) cooling water
D) all of the above (a-c)
E) none of the above (a-c)
Chapter 9
Answer: D

18. In SI units the universal gas constant R is 8.31 J $mol^{-1}K^{-1}$. R is also 0.0820 L atm $mol^{-1}K^{-1}$. Therefore, 1.00 L-atm is equivalent to how many J?
A) 9.87
B) 9.87×10^{-3}
C) 101.3
D) 1.013×10^{5}
E) none of these are correct.
Answer: C

19. For a balloon expanding against atmospheric pressure, the work done on the air in the balloon is
A) positive
B) negative
C) of indeterminate sign
D) zero
E) this cannot be answered without additional information.
Answer: B

20. This is Test Form (look at the top of the page):
A) A
B) B
C) C
D) D

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Extra Credit / Bonus: The following bonus questions are worth just one point (1 pt) each!

Consider the gas-phase reaction

$$H_2\,(g) + (1/2)\,O_2\,(g) \rightleftharpoons H_2O\,(g).$$

Standard gas phase thermodynamic information is available:

$\Delta H°_f\,(H_2) = 0.0$	$S°_f\,(H_2) = 131$ J/mol-K
$\Delta H°_f\,(O_2) = 0.0$	$S°_f\,(O_2) = 205$ J/mol-K
$\Delta H°_f\,(H_2O) = -242$ kJ /mol	$S°_f\,(H_2O) = 189$ J/mol-K

21. What is $\Delta H°_r$ for this reaction?
A) + 121 kJ/mol B) - 121 kJ/mol C) + 242 kJ/mol D) - 242 kJ/mol
E) Cannot be determined from the information given.
Answer: D

22. What is $\Delta S°_r$ for this reaction?
A) + 44 J/mol-K B) - 44 J/mol-K C) + 147 J/mol-K D) -147 J/mol-K
E) Cannot be determined from the information given.
Answer: B
189-(1/2)205-131 = -44

23. What is $\Delta G°_r$ for this reaction at 298K?
A) -255 kJ/mol B) -229 kJ/mol C) +229 kJ/mol D) +255 kJ/mol
E) Cannot be determined using the information given.
Answer: B
-242-(298)(-44/1000) = -229

24. For this reaction, at about what temperature is $\Delta G°_r = 0$?
A) 5.5 K B) 300 K C) 5200 K D) 5500 K
E) Cannot be determined using the information given.
Answer: D
T=242/.044 = 5500K

25. For this reaction, what is the approximate value of $\ln(K_{eq})$ at T = 1000 K?
A) 24 B) 29 C) 34 D) -24
E) Cannot be determined using the information given.
Answer: A
$\Delta G° = \Delta H° - T\Delta S° = -242 - 1000(-0.044) = -198 = -RT\ln(K_{eq})$
$\ln(K_{eq}) = (198000\text{ J/mol})/[(8.31\text{ J/mol K})(1000\text{ K})] = 23.8$

26. The maximum work (in absolute value) obtainable from this reaction at 1000 K, and Q = 0.0025 (Q is the reaction quotient) is approximately:
A) 0 kJ/mol B) 150 kJ/mol C) 200 kJ/mol D) 250 kJ/mol
E) Cannot be determined using the information given.
Answer: D
w = -198000 + 8.3*1000ln(0.0025) = -198000 J/mol – 50000 J/mol = -248 kJ/mol

Print Name_____ Signature _____

1 mole atoms = 6.022×10^{23} *atoms*

$h = 6.626x10^{-34}\ Js$ 1 J (Joule) = 1 kg $\frac{m^2}{s^2}$

1 J (Joule) = .00987 L - atm (or 101.3 J/L - atm)

$c = 3.0x10^{8}\ m/s$

Mass Electron = $9.10939 \times 10^{-31}\ kg$

Mass Proton = $1.67 \times 10^{-27}\ kg$

Mass Neutron = $1.67 \times 10^{-27}\ kg$

$R = 0.0821\frac{L-atm}{mol-K}$ $R = 8.31\frac{J}{mol-K}$

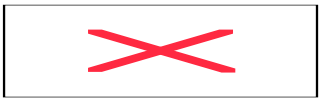
$Vapor\,\mathrm{Pr}essure(H_2O, 373K) = 760torr$

Formal Charge = V – (L + 0.5 S)

V = Number of Valence Electrons

L = Number of Lone Pair Electrons

S = Number of Shared Electrons



$P = X_1 \bullet P^o$

$m = molality = \frac{\text{mol of solute}}{kg \text{ of solvent}}$

$\Delta T_f = -m \bullet K_f$ $\Delta T_b = m \bullet K_b$

$X_1 =$ mole fraction $= \frac{n_1}{n_{total}}$

$\Pi = MRT$

$q = mC\Delta T$ $q_v = nC_V\Delta T$

$q_p = nC_p\Delta T$ $dS = \frac{dq}{T}$

$\Delta G = \Delta H - T\Delta S$ $\Delta G^o = -RT\ln K$ $\Delta G = \Delta G^o + RT\ln Q$

$T_c = \frac{\Delta H}{\Delta S}$ $C_{water} = 4.184\frac{J}{gram\ K}$

$c = \lambda\nu$ $E = mc^2$ $\lambda = \frac{h}{p}$

$\hat{H}\psi = E\psi$ $\Delta x * m\Delta v \geq \frac{h}{4\pi}$

Maximum Occupancy = $2n^2$

$pH = -\log[H^+]$ $pOH = -\log[OH^-]$

$K_w = K_aK_b$ $pH + pOH = 14$

$HA(aq) \leftrightarrow H^+(aq) + A^-(aq)$

$K_a = \frac{[H^+][A^-]}{[HA]}$

$K_w = 1 \times 10^{-14}$ at 25^oC

$B(aq) \leftrightarrow BH^+(aq) + OH^-(aq)$

$K_b = \frac{[BH^+][OH^-]}{[B]}$

$pKa = -\log K_a$ $pKw = 14$ at 25^oC

$\Delta E = q + w$

$w = -P_{ext}\Delta V$

$C_p = \frac{5}{2}R$ (monoatomic ideal gas)

$C_v = \frac{3}{2}R$ (monoatomic ideal gas)

$\Delta H = q_p$ (constant temperature)

$w_{rev} = -nRT\ln\left(\frac{V_2}{V_1}\right)$

E(monatomic) = KE(mol)=3/2 (RT) = 3/2 (PV) KE(particle) = 1/2mu²

Print Na

The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

Answer: B

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