HAND IN
answers recorded
on question paper

Queen's University at Kingston
CHEM112 Final Exam

10–DEC–2018
Time: 3 hour

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Student Number:_____

Name: _____

INSTRUCTIONS:

You will be given the exam paper and a computer–marked sheet on which you will answer all your multiple–choice questions.

- You must use a soft–lead pencil (HB or softer). The scanner will not read ink no matter how black a mark it makes.
- Do not bend or fold the computer sheet in any way or it will become jammed in the scanner.
- Write and Code your name and student number and on the answer sheets in the appropriate spaces. (*Be especially careful to code in your student number properly.*)
- Do not mark the computer answer sheet in any way except to encode the answers. Stray marks can be read by the machine as incorrect answers!
- Make sure you've coded in all the answers. No marks are deducted for wrong answers so DO NOT LEAVE BLANKS! There is exactly one answer for each multiple–choice question. If you think there is more than one correct answer for a particular question, ONLY PUT ONE answer.
- All Multiple Choice questions are worth 1 mark.
- Casio fx–991calculator is best but any non–programmable, non–communication–enabled calculator is acceptable.

PLEASE NOTE:
Proctors are unable to respond to queries about the interpretation of exam questions.
Do your best to answer exam questions as written.

Good luck

1. **All of the following are intensive properties of a substance except:**

   A. melting point
   B. density
   C. mass
   D. specific heat capacity
   E. these are all intensive properties

2. **The formula of chlorous acid is:**

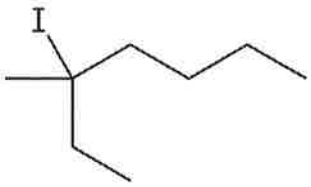
   A. HOCl
   B. $HClO_2$
   C. $HClO_3$
   D. $HClO_4$
   E. HCl

3. ~~3.~~ **A 0.500 g piece of copper is added to 125 mL of 0.100 M $AgNO_3$ solution, and the reaction below proceeds to completion with the formation of solid silver. Balance the equation, determine the limiting reagent and calculate the mass (g) of silver produced:**

   $Cu(s) + AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + Ag(s)$

   A. 1.70
   B. 0.794
   C. 0.849
   D. 1.35
   E. 10.8

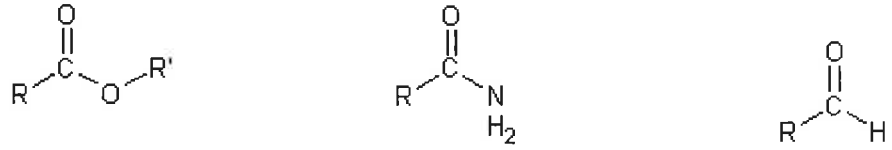
4. ~~4.~~ **The correct name of this structure is:**



   A. 3–Iodo–3–methylheptane
   B. 2–Ethyl–2–iodohexane
   C. 5–Ethyl–5–iodohexane
   D. 3–Iodo–octane
   E. 1–Ethyl–1–iodo–1–methylpentane

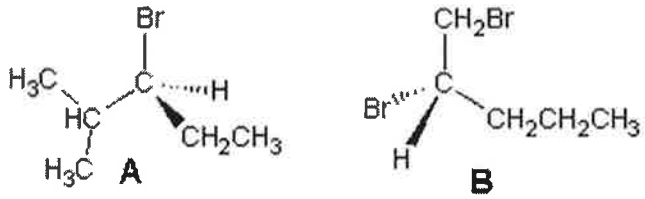
5. Choose the response with the correct names for the three structures:

I) **II)** **III)**



A. I) Carboxylic acid, II) Amide, III) Aldehyde
B. I) Carboxylic acid, II) Amide, III) Ketone
C. I) Ester, II) Amide, III) Aldehyde
D. I) Ester, II) Ketone, III) Aldehyde
E. I) Ether, II) Amide, III) Carboxylic acid

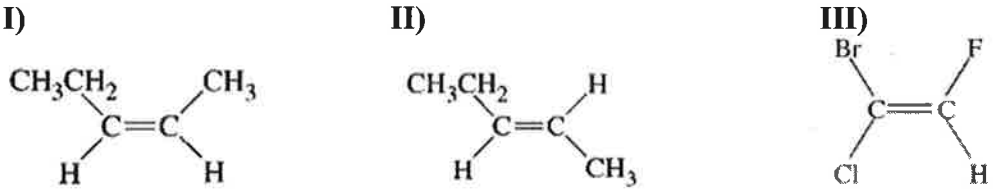
6. Which response has the correct designation of "R" or "S" for the chiral carbons in these compounds:



A. A: R, B: R
B. A: R, B: S
C. A: S, B: R
D. A: S, B: S
E. one of these compounds does not have a chiral carbon

7. Choose the response with the correct designations of the three alkene structures:

I) **II)** **III)**



A. I) Cis, II) Trans, III) Cis
B. I) Trans, II) Cis, III) Trans
C. I) Cis, II) Trans, III) E
D. I) Z, II) Trans, III) Z
E. I) Cis, II) Trans, III) Z

8. If gas volume is doubled but the temperature remains constant:

A. the pressure stays the same
B. the molecules move faster
C. the final pressure is twice the pressure before the volume change.
D. the molecules move slower
E. the final pressure is 1/2 of the pressure before the volume change.

9. A 5.0 L sealed vessel under vacuum is filled with 8.3 g of neon gas. What is the pressure (in kPa) of the vessel at 25.0 °C:

A. 17.1
B. 4115
C. 204
D. 5098
E. 1020

10. A container is filled with 200.0 g of acetylene gas, C_2H_2, and is at 0 °C and 1.00 atm. What is the volume (in L) of the container?

A. 4480
B. 1.31×10^5
C. 320
D. 0.630
E. 172

11. If a 1 L container of CH_4 is compared to a 1 L container of H_2, both at 25 °C and 100 kPa, then which of the following statements is correct:

A. the CH_4 and H_2 molecules have the same average speed
B. there are more H_2 molecules than CH_4 molecules
C. the average kinetic energy of the CH_4 molecules is greater than that of the H_2 molecules
D. the CH_4 molecules are, on average, moving more slowly than the H_2 molecules
E. the mass of one liter of CH_4 equals the mass of one liter of H_2

12. The density of a diatomic gas is 1.672 g/L at 273 K and 100 kPa. The gas is:

A. H_2
B. N_2
C. O_2
D. Cl_2
E. F_2

13. Calculate the wavelength in meters of light absorbed by an electron in an atom of hydrogen that makes a transition from $n = 3$ to $n = 6$.

A. 1.09×10^{-6} m
B. 8.22×10^{-7} m
C. 3.28×10^{-6} m
D. 1.83×10^{-7} m
E. 1.65×10^{-11} m

14. What is the smallest acceptable value for the missing quantum number?

$n = ?, \ell = 2, m\ell = 0, m_s = +1/2$

A. 1
B. 2
C. 3
D. 4
E. 5

15. **Which of the following orbitals have their lobes aligned along the *y* axis?**

I) d_{xy}
II) $d_{x^2-y^2}$
III) p_y
IV) d_{yz}

A. II and III
B. I and IV
C. I and II
D. II and IV
E. I and III

16. Which series below represents the correct order of orbital filling in a multielectron atom?

A. 5*d*, 4*f*, 6*s*, 6*p*
B. 4*f*, 6*s*, 5*d*, 6*p*
C. 4*f*, 5*d*, 6*s*, 6*p*
D. 6*s*, 4*f*, 5*d*, 6*p*
E. 6*s*, 6*p*, 5*d*, 4*s*

17. The quantum numbers of the last electron of arsenic could be:

A. $n = 4, \ell = 2, m\ell = 1, m_S = +1/2$
B. $n = 4, \ell = 1, m\ell = 1, m_S = +1/2$
C. $n = 3, \ell = 1, m\ell = 1, m_S = +1/2$
D. $n = 4, \ell = 3, m\ell = 1, m_S = +1/2$
E. $n = 4, \ell = 1, m\ell = 1/2, m_S = 0$

18. Which of the following isoelectronic species has the largest radius?

A. Ne
B. F^-
C. Mg^{2+}
D. Na^+
E. O^{2-}

19. Which of the following reactions gives a positive value for the electron affinity?

A. $S^-(g) + e^- \rightarrow S^{2-}(g)$
B. $O(g) + e^- \rightarrow O^-(g)$
C. $S(g) + e^- \rightarrow S^-(g)$
D. $Br(g) + e^- \rightarrow Br^-(g)$

20. As indicated by Lewis structures, which of the following molecules would probably be unstable?

A. NH_3
B. N_2H_6
C. SF_4
D. CH_2F_2
E. SiH_4

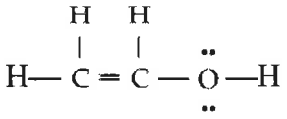
21. Which of the following species exhibits resonance?

A. OF_2
B. ClO_3^-
C. N_2
D. PCl_5
E. BrF_3

22. After drawing the Lewis dot structure for IF_7, determine the number of single bond(s), double bond(s), and lone pair(s) on the central atom.

A. single bond(s) = 3, double bond(s) = 2, lone pair(s) = 1
B. single bond(s) = 7, double bond(s) = 0, lone pair(s) = 1
C. single bond(s) = 7, double bond(s) = 0, lone pair(s) = 0
D. single bond(s) = 1, double bond(s) = 0, lone pair(s) = 0
E. single bond(s) = 4, double bond(s) = 0, lone pair(s) = 0

23. For the molecule



A. the geometry about O is linear
B. the hybridization on O is *sp*
C. O is not hybridized
D. both carbons are sp^2 hybridized
E. there are two π bonds between the two carbons

24. What is the hybridization of the S atom in SF_4?

A. sp^3d
B. sp^3
C. sp^3d^2
D. spd^2

25. According to MO theory, which is the INCORRECT statement for $[C_2]^-$ ion?

A. The Bond Order (BO) is 2.5.
B. There is one unpaired electron.
C. The σ_{2p} orbital has two electrons.
D. The molecule is paramagnetic.
E. There are 9 electrons in the molecular orbitals.

26. Which is the correct electron configuration for $[O_2]^-$ ion?

A. $(\sigma_{2s})^2(\sigma_{2s}^*)^2(\sigma_{2p})^2(\pi_{2p})^2(\pi_{2p}^*)^3$
B. $(\sigma_{2s})^2(\sigma_{2s}^*)^2(\sigma_{2p})^2(\pi_{2p})^4(\pi_{2p}^*)^3$
C. $(\sigma_{2s})^2(\sigma_{2s}^*)^2(\sigma_{2p})^1(\pi_{2p})^4(\pi_{2p}^*)^2$
D. $(\sigma_{2s})^2(\sigma_{2s}^*)^2(\sigma_{2p})^2(\pi_{2p})^4(\pi_{2p}^*)^1$
E. $(\sigma_{2s})^2(\sigma_{2s}^*)^1(\sigma_{2p})^2(\pi_{2p})^6(\pi_{2p}^*)^1$

27. 1674 J of heat are absorbed by 25.0 mL of NaOH solution (d = 1.10 g/mL, specific heat = 4.10 J/g °C). The temperature of the NaOH solution goes up by how many degrees?

A. 14.8 °C
B. 18.0 °C
C. 17.2 °C
D. 14.2 °C
E. 19.1 °C

28. From the following thermochemical equations, calculate $\Delta_r H°$ for the reaction:

$$SO_2(g) + NO_2(g) \rightarrow SO_3(g) + NO(g)$$
$$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g) \quad \Delta_r H° = -197.8\ kJ/mol$$
$$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g) \quad \Delta_r H° = -114.14\ kJ/mol$$

A. –83.66 kJ /mol
B. –311.9 kJ/mol
C. +155.9 kJ/mol
D. –155.9 kJ/mol
E. –41.83 kJ/mol

29. The heat of combustion of several fuels are listed in the table below. On a per gram basis, which fuel releases the most energy?

Fuel	$\Delta_r H_{comb}$ (kJ/mol)
C(s)	–393.5
$CH_4(g)$	–890.8
$CH_3OH(l)$	–726.1
$C_3H_8(g)$	–2219.2
$H_2(g)$	–285.8

A. C(s)
B. $CH_4(g)$
C. $CH_3OH(l)$
D. $C_3H_8(g)$
E. $H_2(g)$

30. Calculate ΔU for a system that loses 475 kJ of heat and does 155 kJ of expansion work on the surroundings.

A. –630 kJ
B. –320 kJ
C. +630 kJ
D. +320 kJ

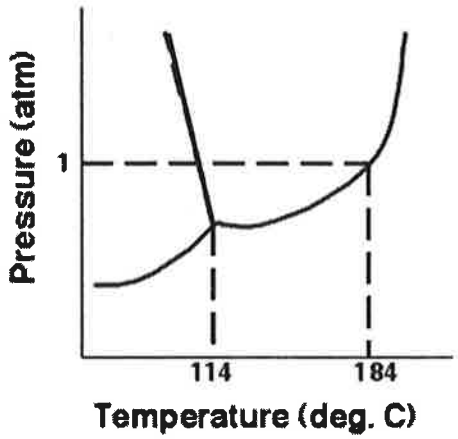
31. The specific heat capacity of solid copper metal is 0.385 $J \cdot g^{-1} \cdot K^{-1}$. How many joules of heat are needed to raise the temperature of a 1.55 kg block of copper from 33.0 °C to 77.5 °C?

A. 1.79×10^5 J
B. 26.6 J
C. 2.66×10^4 J
D. 5.58×10^{-6} J
E. 0.00558 J

32. Calculate the work, *w*, gained or lost by the system when a gas expands from 15 L to 40 L against a constant external pressure of 1.5199 bar.

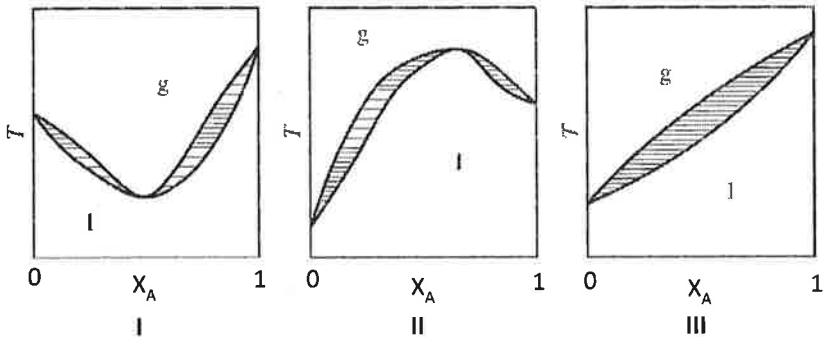
A. –6.1 kJ
B. –3.8 kJ
C. +3.8 kJ
D. +6.1 kJ

33. According to the following phase diagram for a substance X, which of the following statements is FALSE?



A. The melting point of X varies little with pressure.
B. At 125°C, X will boil if the pressure is lowered enough.
C. X is liquid at 120°C and 1 atm.
D. The normal boiling point of X is 184°C.
E. X could sublime at low pressures.

34. Consider the vapor equilibrium diagrams for mixtures below:



Which of the following statements is FALSE?

A. "II" represents a maximum boiling azeotrope
B. "III" represents an ideal solution according to Raoult's Law
C. "I" forms an azeotrope at approximately 0.5 mole fraction for "X_A"
D. "II" is considered a positive azeotrope
E. "III" indicates the components can be separated by fractional distillation

35. Which of the following statements about viscosity are true:

I) Viscosity is liquid's resistance to flow.
II) Viscosity decreases with a decrease in temperature.
III) Viscosity is not related to the forces between molecules in a liquid.
IV) Viscous liquids have low rate flows.

A. I) and IV)
B. I) and III)
C. I) and II)
D. II) and IV)
E. III and IV)

36. The normal boiling point of acetone is 56.2 °C and the molar heat of vaporization is 32.0 kJ/mol. At what temperature will acetone boil under a pressure of 50.0 mmHg?

A. 156 °C
B. 6.0 °C
C. –6.0 °C
D. 40.7 °C
E. 73.6 °C

37. What would be the appropriate equilibrium temperature of a system obtained by adding 25.0 g of ice at 0 °C to 250.0 mL of "hot" (80 °C) coffee, assuming that the heat capacity and density of the coffee are the same as for pure water (4.18 J g^{-1} $°C^{-1}$ and 0.997 g mL^{-1}), and also assuming negligible heat transfer with the surroundings? [For water, $\Delta_{fus}H$ = 6.02 kJ/mol.]

A. 33 °C
B. 40 °C
C. 65 °C
D. 73 °C
E. 79 °C

38. Consider a parallelepiped with all edges being equal in length. There is an atom at each corner and one in the absolute center. This is a _____.

A. face–centered cubic cell
B. simple cubic cell
C. unit cell
D. body-centered cubic cell
E. hexagonal unit cell

39. Which of the following compounds exhibits hydrogen bonding?

A. CH_3Cl
B. HI
C. CH_3OCH_3
D. NH_3

40. The heat of vaporization of water at 100 °C is 40.66 kJ mol^{-1}. Calculate the quantity of heat that is absorbed/released when 9.00 g of steam condenses to liquid water at 100 °C.

A. 20.3 kJ of heat are absorbed.
B. 20.3 kJ of heat are released.
C. 81.3 kJ of heat are absorbed.
D. 81.3 kJ of heat are released.

Data/Formula Sheet

Symbol	Value
R	8.31451 J K^{-1} mol^{-1} 0.08206 L–atm mol^{-1} K^{-1}
k_b	1.3807×10^{-23} J K^{-1}
N_A	6.0221×10^{23} mol^{-1}
F	96485. C mol^{-1}
e	1.6022×10^{-19} C
h	6.6261×10^{-34} J s
m_p	1.6726×10^{-27} kg
m_e	9.1094×10^{-31} kg
R_H	2.179×10^{-18} J or 1.09687×10^{7} m^{-1}
c	2.9979×10^{8} m s^{-1}

	1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 H 1.008																	2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 18.99	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.1	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.84	27 Co 58.99	28 Ni 58.34	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 73.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.8
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 99	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 138.9	73 Ta 181.0	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 209	85 At 210	86 Rn 222
7	87 Fr 223	88 Ra 226	89 Ac 227															

6	58 Ce 140	59 Pr 141	60 Nd 144	61 Pm 145	62 Sm 150	63 Eu 152.0	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173.0	71 Lu 175.0
7	90 Th 232	91 Pa 231.0	92 U 238.0	93 Np 237	94 Pu 244	95 Am 243	96 Cu 247	97 Bk 247	98 Cf 251	99 Es 252	100 Fm 257	101 Md 258	102 No 259	103 Lr 262

1atm = 101.325 kPa = 760 mm Hg = 760 torr | 750 mm Hg = 100 kPa = 1 bar

$1L = 1\ dm^3$ | $0^0C = 273.15\ K$ | $E = h\nu$ | $c = \lambda\nu$ | $\lambda = \frac{h}{mv}$ | $\left(P + \frac{n^2a}{V^2}\right)(V - nb) = nRT$ | $\Pi V = nRT$

$\Delta H = \sum_{broken} BE - \sum_{formed} BE$ | $d = m/V$ | $E = h\nu = R_H\left|\frac{1}{n_1^2} - \frac{1}{n_2^2}\right|$ | $x(A) + x(B) + \ldots = 1$ | $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$P_1V_1 = P_2V_2$ / $PV = nRT$ / $w = -P_e\Delta V = -\Delta n_{gas}RT$ | $\Delta U = q + w$ | $\Delta U = q_v$ | $\Delta H = q_p$

$p_B = x_BK_H$ / $p_A + p_B + \ldots = P$ | $y_A = \frac{p_A}{p_A + p_B} = \frac{x_AP_A^*}{x_AP_A^* + (1 - x_A)P_B^*}$ | $y_B = \frac{p_B}{p_A + p_B} = \frac{(1 - x_A)P_B^*}{x_AP_A^* + (1 - x_A)P_B^*}$

$C = \frac{q}{\Delta T}$ | $C_V = \frac{\Delta U}{\Delta T}$ | $C_P = \frac{\Delta H}{\Delta T}$ | $C_P - C_V = R$ | $p_A = x_AP_A^*$

$\left(P + \frac{a}{V_m^2}\right)(V_m - b) = RT$ | $a = \frac{27R^2T_C^2}{64P_C}$ | $b = \frac{RT}{8P_C}$ | $\ln\left(\frac{P_2^*}{P_1^*}\right) = -\frac{\Delta H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ | $u_{rms} = \sqrt{\frac{3RT}{M}}$

$\Delta S^o = \sum S^o(P) - \sum S^o(R)$ | $\Delta H_T^o = \Delta H_{298}^o + \Delta C_P(T - 298)$ | $\Delta H^o = \sum \Delta H_f^o(P) - \sum \Delta H_f^o(R)$

| $KE = \frac{1}{2}mv^2$ | $h\nu = KE + \phi$ | $M = m/n$ | $\Delta H = \Delta U + P\Delta V$