Answer all questions on scantron sheet provided.

QUEEN'S UNIVERSITY MIDYEAR EXAMINATION
FACULTY OF ARTS AND SCIENCE
DEPARTMENT OF CHEMISTRY

CHEM112, ALL SECTIONS, DR. JOHN CARRAN
December 17, 2015

INSTRUCTIONS TO STUDENTS:
This examination is 3 HOURS in length.
There is ONE section to this examination.
There are 45 multiple choice questions.
There are 15 pages including this cover sheet, the data sheet and periodic table
Please answer all questions on the scantron sheet provided
Answer ALL questions. No marks are deducted for incorrect answers

The following aids are allowed:
Arts and Science approved calculator

GOOD LUCK!

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

READ QUESTIONS VERY CAREFULY

MARK SCANTRON ANSWERS IN PENCIL NOT INK

MAKE SURE YOUR STUDENT NUMBER IS ON THE SCANTRON SHEET

Answer all questions on scantron sheet provided.

MULTIPLE CHOICE-ANSWER ALL 45 QUESTIONS

1) Groups, or families, on the periodic table are:
A) vertical columns of elements with similar properties
B) horizontal rows of elements with increasing atomic numbers
C) named for the first elements in the series; such as "actinides"
D) extremely reactive with each other
E) elements that all occur naturally in the same state

2) What is the frequency associated with radiation of 4.59×10^{-8} cm wavelength?
A) $6.54 \times 10^{17} \text{ s}^{-1}$
B) $6.54 \times 10^{15} \text{ s}^{-1}$
C) $1.53 \times 10^{-8} \text{ s}^{-1}$
D) 13.8 s^{-1}
E) $2.18 \times 10^{7} \text{ s}^{-1}$

3) The symbol "n" in the Bohr theory of atomic structure refers to:
A) the energy of the electrons.
B) the total energy of the atom.
C) the number of electrons in a shell.
D) the shell in which an electron is found.
E) the number of orbits in an atom.

4) What is the energy in joules of the 656 nm spectral line of hydrogen?
A) $4.35 \times 10^{-31} \text{ J}$
B) $3.03 \times 10^{-19} \text{ J}$
C) $1.30 \times 10^{-22} \text{ J}$
D) $3.03 \times 10^{-28} \text{ J}$
E) $1.45 \times 10^{-48} \text{ J}$

5) Calculate the wavelength in meters of light absorbed by an electron in an atom of hydrogen as it moves from $n = 3$ to $n = 6$.
A) $1.09 \times 10^{-6} \text{ m}$
B) $8.22 \times 10^{-7} \text{ m}$
C) $3.28 \times 10^{-6} \text{ m}$
D) $1.83 \times 10^{-7} \text{ m}$
E) $1.65 \times 10^{-11} \text{ m}$

6) Calculate the deBroglie wavelength of a ball of mass 125 grams and velocity 90 m/s.
A) 0.59 m
B) 5.9×10^{-31} m
C) 5.9×10^{-35} m
D) 590 m
E) 1.7×10^{34} m

7) The possible values of the magnetic quantum number, m_ℓ, of a $3p$ electron are:
A) 0, 1, 2
B) 2, 1, 0, -1, -2
C) 0
D) -1, 0, +1
E) +1, -1

8) "One places electrons into orbitals one by one from low energy to high energy" is one way of stating the:
A) Aufbau principle
B) Hund's Rule
C) Heisenberg Principle
D) Pauli Exclusion Principle
E) Rydberg's Principle

9) To what uncertainty, in pm, can the position of an electron traveling at 1.89×10^5 m/s be measured if the uncertainty of the speed is 2.00%?
A) 765
B) 654
C) 8.33×10^4
D) 1.53×10^5
E) 1.53×10^4

10) The similar chemical behavior of the elements in a given group in the periodic table is best accounted for by the fact that atoms of these elements have:
A) the same number of isotopes
B) the same number of electrons
C) the same number of electrons in the outermost (valence) shell
D) similar nuclear structures
E) the same number of protons

Answer all questions on scantron sheet provided.

11) Which of the following occurs for the representative elements going left to right across the period?
A) Electronegativity decreases.
B) Atomic size increases.
C) Forces of attraction between electron and nucleus increase because nuclear charge increases.
D) The outer electrons are held more weakly.
E) none of these

12) Choose the species from which one electron could most easily be removed.
A) Cl
B) K^+
C) K
D) Ca^+
E) Ar

13) Arrange the following elements in order of increasing metallic character: Al, Pt, Cd.
A) Cd < Pt < Al
B) Al < Pt < Cd
C) Al < Cd < Pt
D) Cd < Al < Pt
E) Pt < Cd < Al

14) Which of the following species contains a triple bond?
A) NH_3
B) $HCCl_3$
C) NO_3^-
D) CO_3^{2-}
E) CN^-

15) Which of the following species exhibits resonance?
A) OF_2
B) ClO_3^-
C) N_2
D) PCl_5
E) BrF_3

16) Which of the following has a molecular structure best described as involving an "incomplete octet"?
A) OF_2
B) BF_3
C) CF_4
D) NF_3
E) F_2

17) Which of the following sets contains only linear molecules?
A) CO_2, HCN, O_2
B) H_2S, HCN, CO_2
C) H_2O, CO, Cl_2
D) H_2S, CO, CO_2
E) BF_3, Cl_2, O_2

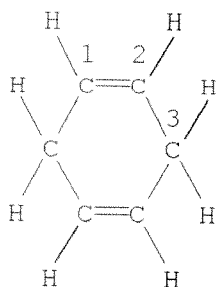18) What is the correct molecular geometry for the carbon atom in urea $(NH_2)_2CO$?
A) Tetrahedral
B) T-Shaped
C) Trigonal planar
D) Trigonal pyramidal
E) Trigonal bipyramidal

19) According to the principles of VSEPR applied on ICl_5, which of the following is INCORRECT?
A) VSEPR formula = AX_5E
B) molecular geometry = square pyramid
C) hybridization = $sp3d$
D) electron pair geometry = octahedral
E) one lone pair and 5 bonding pairs

20) Which statement is correct for the structure shown?

A) The molecule contains a total of 16 σ bonds.
B) Carbon no. 1 is described by sp hybridization.
C) The molecule contains a total of four π bonds.
D) Carbon no. 3 is described by sp^3 hybridization.
E) The molecule contains a delocalized π bond system.

21) π bonds:
A) are the only kind of bonds present in double bonds
B) have very little electron density along the internuclear axis
C) are formed by endwise overlap of p orbits
D) are formed from hybrid orbitals
E) are formed from s orbitals

22) According to MO theory, which is the INCORRECT statement for C_2^-?
A) The 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.

23) Which of the following involves delocalized π bonds?
A) acetylene (C_2H_2)
B) benzene (C_6H_6)
C) carbon tetrachloride (CCl_4)
D) dichlorodifluoromethane (CF_2Cl_2)
E) ethylene (C_2H_4)

24) The IUPAC name of *tert*-butyl group is:
A) 1,1-dimethylethyl
B) 1,1-dimethylethane
C) 1,2-dimethylethyl
D) 1-methylpropyl
E) 2-methylpropyl

25) Find the answer that has correct both the two structures of cis-1-isopropyl-4-methylcyclohexane and their relative stability (stability is indicated with ">" meaning "more stable than").
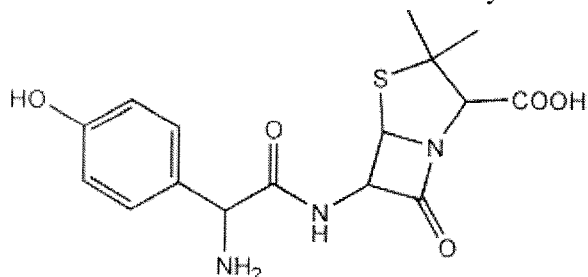
A)

B)

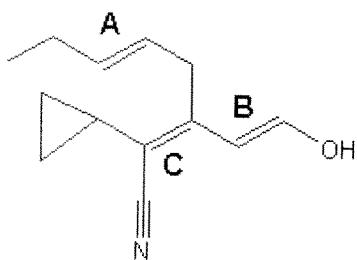C)

D)

26) How many chiral carbon atoms can you find in the molecule below?
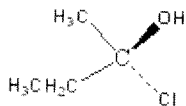
A) 1
B) 2
C) 3
D) 4
E) 5

27) Choose the best configuration assignments for the three double bonds, labeled **A**, **B** and **C**, in the following compound:
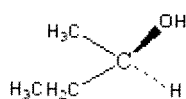
A) **A** is *trans*, **B** is *trans*, and **C** is Z
B) **A** is *cis*, **B** is *cis*, and **C** is Z
C) **A** is *trans*, **B** is *trans*, and **C** is E
D) **A** is *trans*, **B** is *trans*, and **C** is *cis*
E) **A** is *trans*, **B** is *trans*, and **C** is *trans*

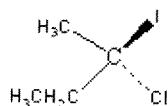28) Which of the following chiral compounds is(are) S enantiomer(s)?
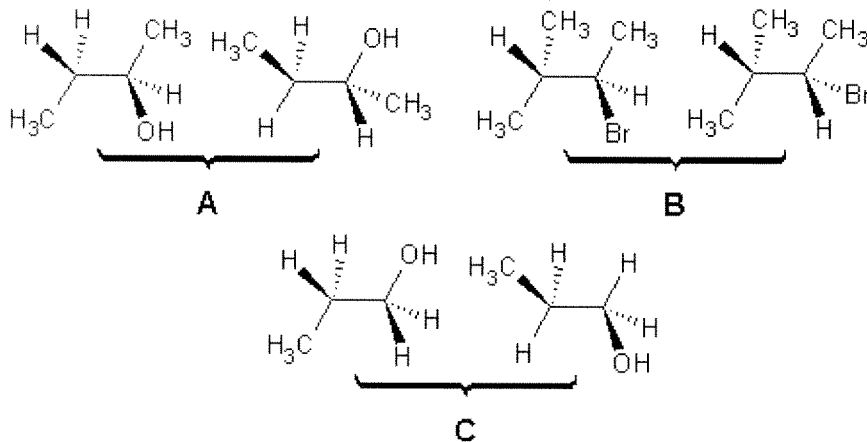I.   II.   III.
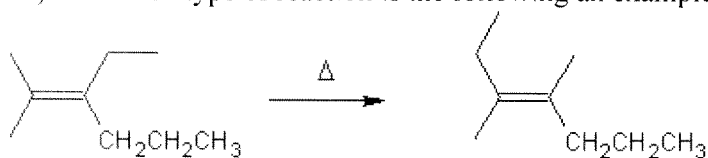
A) I
B) II
C) III
D) I + II
E) II + III

29) Are the following three pairs of structural formulas (pairs **A**, **B**, and **C**) representing identical molecules, conformers of the same molecule, or enantiomers?

A) **A** is a pair of identical molecules, **B** is a pair of enantiomers and **C** is a pair of conformers
B) **A** and **C** are pairs of conformers, and **B** is a pair of enantiomers
C) **A** is a pair of conformers, **B** is a pair of enantiomers and **C** is a pair of identical molecules
D) **A** is a pair of identical molecules, **B** and **C** are pairs of enantiomers
E) **A** and **B** are pairs of enantiomers, and **C** is a pair of conformers

30) For which type of reaction is the following an example?

A) substitution
B) elimination
C) polymerization
D) rearrangement
E) addition

31) We can promote S_N2 over S_N1 reactions if we:
I)   use a substrate that gives a primary carbocation and not tertiary carbocation
II)   use a sterically hindered substrate
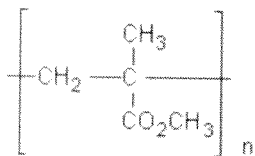III)   use a polar protic solvent
A) I)
B) II)
C) III)
D) I) and III)
E) II) and III)

32) Which of the following groups is a *meta* director during electrophilic aromatic substitution?
A) $-NH_2$
B) $-OCH_3$
C) $-Br$
D) $-C\equiv N$
E) $-OCOC_2H_5$

33) Which are the most probable reactions and mechanisms in which tertiary haloalkanes participate?
I)   Substitution, S_N1
II)   Substitution S_N2
III)   Elimination E1
IV)   Elimination E2
V)   Addition
A) II), III) and IV)
B) I), IV) and V)
C) II), III) and V)
D) I), III) and IV)
E) III), IV), V)

34) What type of polymerization reaction occurred to produce the following polymer?

Plexiglass
(polymethyl methacrylate)

A) step-reaction polymerization
B) elimination reaction
C) chain-reaction polymerization
D) condensation polymerization
E) propagation polymerization

35) What is the difference between atactic polymer and isotactic polymer?
A) Atactic polymer has an irregular structure while in isotactic polymer identical functional groups have the same orientation on the polymer chain.
B) Atactic polymer has a regular zig-zag structure while in isotactic polymer identical functional groups have the same orientation on the polymer chain.
C) Atactic polymer has the same functional groups on one side of the polymer structure while in isotactic polymer has random distribution of functional groups in its structure.
D) Atactic polymer has an irregular structure while in isotactic polymer identical functional alternate back and forth along the polymer chain.
E) Atactic polymer has identical functional groups alternating back and forth along the polymer chain while in isotactic polymer identical functional groups have the same orientation on the polymer chain.

36) You need to substitute one hydrogen with bromine on an aromatic ring. What reagents do you use?
A) HBr and $FeBr_3$ as catalyst
B) Br_2 and heat
C) Br_2 and $FeBr_3$ as catalyst
D) a mixture of HBr and conc. H_2SO_4
E) Br_2 and radiation (hυ)

37) Classify the following reaction steps as initiation, propagation or termination.
A: $Br\text{-}Br \rightarrow 2Br\cdot$
B: $H_3CH_2C\cdot + Br\cdot \rightarrow CH_3CH_2Br$
C: $2H_3CH_2C\cdot \rightarrow CH_3CH_2CH_2CH_3$
A) Step A is initiation and steps B and C are propagation
B) Steps A and B are initiation and step C is termination
C) Step A is initiation, step B is termination and step C is propagation
D) Step A is initiation, step B is propagation and step C is termination
E) Step A is initiation and steps B and C are termination

38) Amino acids are joined into proteins by:
A) a 3'-5' linkage
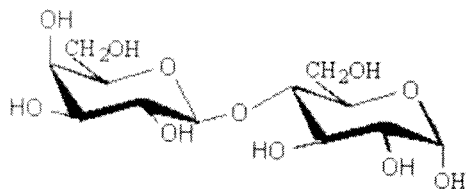B) a beta 1-4 linkage
C) DNA
D) an ester
E) peptide bonds

39) At the isoelectric point, an amino acid has what charges?
A) + and -
B) none
C) + only
D) - only
E) multiple charges

40) Compounds which are optical isomers (stereoisomers) of one another but differ in physical and chemical properties are known as what?
A) geometric isomers
B) enantiomers
C) racemic compounds
D) allotropes
E) diastereomers

41) Lactose, the sugar found in milk, is a disaccharide of galactose and glucose in a 1,4 linkage. What is the configuration of the 1,4 linkage between the two glycoses (sugar units) in lactose?

A) β configuration
B) α configuration
C) D configuration
D) axial configuration
E) chair configuration

42) When a liquid is in equilibrium with its vapor in a closed container:
A) the rate at which molecules from the liquid phase enter the gas phase exactly equals the rate at which molecules from the gas phase pass into the liquid phase
B) a change in temperature will not change the pressure in the container
C) the amount of gas in the container must exactly equal the amount of liquid
D) molecules cannot go from the liquid phase to the gas phase because the amount of liquid in the container is constant
E) the vapor will gradually change back to the liquid state, that is, no vapor will be left

43) The relationship between the vapor pressure of a liquid and temperature can be expressed by the Clausius-Clapeyron equation:

$$Log[P_2/P_1] = [\Delta H_{vap}/R] \times [1/T_1 - 1/T_2]$$

Ethanol (C_2H_5OH) has a normal boiling point of 78.3°C and, with $\Delta H_{vap} = 39.3$ kJ/mol. What is the vapor pressure of ethanol at 50.0°C?
A) 118 torr
B) 234 torr
C) 354 torr
D) 485 torr
E) 670 torr

44) Predict the major product for the reaction: 1-butene + HI →
A) $CH_2ICH_2CH_2CH_3$
B) $CH_2ICH=CHCH_3$
C) $CH_2=CICH_2CH_3$
D) $CH_3CHICH_2CH_3$
E) $CH_3CI_2CH_2CH_3$

45) Liquid and vapor phases of a substance become indistinguishable at the _____.
A) triple point
B) normal point
C) permanent point
D) critical point
E) absolute point

THE END

CHECK YOUR ANSWERS

Answer all questions on scantron sheet provided.

Data Sheet

Symbol	Value
e	1.6022×10^{-19} C
h	6.6261×10^{-34} Js
proton mass (m_p)	1.6726×10^{-27} kg
electron mass (m_e)	9.1094×10^{-31} kg
R_H	2.179×10^{-18} J
c	2.9979×10^{8} ms^{-1}
a_0	5.29177×10^{-11} m

$$c = v\lambda \quad E = hv \qquad KE = \frac{1}{2}mv^2 \quad hv = \Phi + \frac{1}{2}mv^2 \qquad r_n = n^2 a_0 \qquad E_n = \frac{-R_H}{n^2}$$

$$\Delta E = hv = R_H\left(\frac{1}{n_b^2} - \frac{1}{n_i^2}\right) \qquad \lambda = \frac{h}{p} = \frac{h}{mv} \quad \Delta x \Delta p \geq \frac{h}{4\pi} \qquad Z_{eff} = Z - S$$

Symbol	Value/units
R	8.31451 J.K^{-1}.mol^{-1}
	8.31451 L.kPa.K^{-1}mol^{-1}
	8.31451 x 10^{-2} L.bar.K^{-1}mol^{-1}
	0.08206 L.atm.mol^{-1}.K^{-1}
K_B = R/N$_A$	1.3807 x10^{-23} J.K^{-1}
N$_A$	6.0221 x 10^{23} mol^{-1}
760 Torr = 101.325KPa = 1atm =760 mmHg	
1 Pa	1 N.m^{-2}

PV=nRT $P_1V_1 = P_2V_2$ X(A)= n(A)/n(A)+n(B) +....   X(A)+X(B) +.....=1 density=m/V

c(A)=n(A)/V $P_B = X_B K_H$ M=m/n $P_A + P_B + ... = P_{Tot}$ $P_A = x_A P_{Tot}$ T=t + 273.15

$V_1/T_1 = V_2/T_2$ $P_1V_1/n_1T_1 = P_2V_2/n_2T_2$ $u_{rms} = \sqrt{\dfrac{3RT}{M}} = \sqrt{\dfrac{3k_B T}{m}}$ RH=P$_{(H2O)}$/P*$_{(H2O)}$

$$\ln\frac{P_2^*}{P_1^*} = -\frac{\Delta H_V^\circ}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\frac{rate\,of\,effusion\,of\,A}{rate\,of\,effusion\,of\,B} = \frac{(u_{rms})_A}{(u_{rms})_B} = \sqrt{\frac{3RT/M_A}{3RT/M_B}} = \sqrt{\frac{M_B}{M_A}} \text{ and others}$$

$P_A = X_A P^\circ_A$ or $P_A = X_A P^*_A$

Answer all questions on scantron sheet provided.

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 H 1.008																	2 He 4.003
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
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
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
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
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
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