Student Name: ____________________ **Student No:** ______________________

Chemistry 1AA3 **Final Exam** **April 22, 2010**

McMaster University VERSION 1

Instructor: P. Berti, P. Hatala, H. Stover, J. Valliant

Duration: 3 Hours

This test contains 29 numbered pages printed on both sides. There are 37 multiple-choice questions appearing on pages numbered 3 to 26. Page 28 includes some useful data and equations. There is a periodic table on page 29. You may tear off the last page to view the periodic table and to do your rough work.

You must enter your name and student number on the question sheets, as well as on the answer sheet. Your invigilator will be checking your student card for identification.

You are responsible for ensuring that your copy of the question paper is complete. Bring any discrepancy to the attention of your invigilator.

Questions 1 to 32 are each worth 2 marks, questions 33 - 37 are each worth 3 marks; the total marks available are 79. There is no additional penalty for incorrect answers.

BE SURE TO ENTER THE CORRECT VERSION OF YOUR TEST (shown near the top of page 1), IN THE SPACE PROVIDED ON THE ANSWER SHEET.

ANSWER ALL QUESTIONS ON THE ANSWER SHEET, IN PENCIL.
Instructions for entering multiple-choice answers are given on page 2.

SELECT ONE AND ONLY ONE ANSWER FOR EACH QUESTION from the answers (A) through (E). No work written on the question sheets will be marked. The question sheets may be collected and reviewed in cases of suspected academic dishonesty.

Academic dishonesty may include, among other actions, communication of any kind (verbal, visual, etc.) between students, sharing of materials between students, copying or looking at other students' work. If you have a problem please ask the invigilator to deal with it for you. Do not make contact with other students directly. Try to keep your eyes on your own paper – looking around the room may be interpreted as an attempt to copy.

Only Casio FX 991 electronic calculators may be used; but they must NOT be transferred between students. Use of periodic tables or any aids, other than those provided, is not allowed.

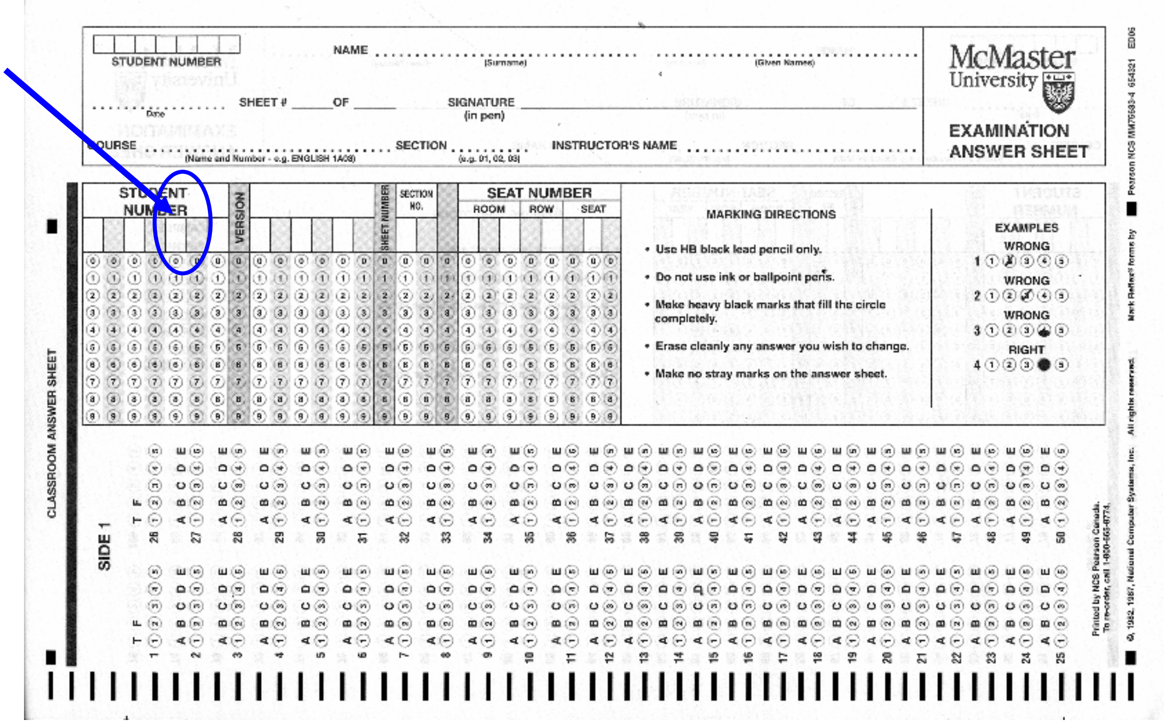
Student Name: ____________________ **Student No:** ______________________

OMR EXAMINATION – STUDENT INSTRUCTIONS

NOTE: IT IS YOUR RESPONSIBILITY TO ENSURE THAT THE ANSWER SHEET IS PROPERLY COMPLETED: YOUT EXAMINIATION RESULT DEPENDS UPON PROPER ATTENTION TO THESE INSTRUCTIONS.

The scanner, which reads the sheets, senses the bubble shaded areas by their non-reflection of light. A heavy mark must be made, completely filling the circular bubble, with an HB pencil. Marks made with a pen will NOT be sensed. Erasures must be thorough or the scanner will still sense a mark. Do NOT use correction fluid on the sheets. Do NOT put any unnecessary marks or writing on the sheet.

1. On SIDE 1 (red side) of the form, in the top box, in pen, print your student number, name, course name, and the date in the spaces provided. Then you MUST write your signature, in the space marked SIGNATURE.
2. In the second box, with a pencil, mark your student number, exam version number in the space provided and <u>fill in the corresponding bubble numbers underneath</u>.
3. Answers: mark only ONE choice from the alternatives (A,B,C,D,E) provided for each question. The question number is to the left of the bubbles. Make sure that the number of the question on the scan sheet is the same as the number on the test paper.
4. Pay particular attention to the Marking+ Directions on the form.
5. Begin answering the question using the first set of bubbles, marked “1”.



STUDENT NUMBER

NAME .... (Surname) .... (Given Names)

.... Date SHEET # _____ OF _____ SIGNATURE (in pen) ____________________

COURSE .... (Name and Number - e.g. ENGLISH 1A03) SECTION .... (e.g. 01, 02, 03) INSTRUCTOR'S NAME ....

McMaster University

EXAMINATION ANSWER SHEET

STUDENT NUMBER | VERSION | SHEET NUMBER | SECTION NO. | SEAT NUMBER: ROOM | ROW | SEAT

MARKING DIRECTIONS

- Use HB black lead pencil only.
- Do not use ink or ballpoint pens.
- Make heavy black marks that fill the circle completely.
- Erase cleanly any answer you wish to change.
- Make no stray marks on the answer sheet.

EXAMPLES

WRONG
1 ① ✗ ③ ④ ⑤

WRONG
2 ① ② ✓ ④ ⑤

WRONG
3 ① ② ③ ◕ ⑤

RIGHT
4 ① ② ③ ● ⑤

Continued on next page...

You are writing VERSION 1 of this test. Make sure you have correctly entered your version number (“1”) in the correct column on your scan sheet (see p. 2 for details).

Section #1 – These questions are worth two marks each.

____ 1. A student determines the isoelectric point (the pH corresponding to zero net charge) of a protein in an aqueous solution by lowering the pH until precipitation of the protein is observed. During this process, the student records an initial pH of 6.25 (protein is in solution), then upon addition of acid, the pH decreases to 5.75 and the protein is found to have precipitated from solution. The student should record the isoelectric point of the protein as:

a. 6.00 ± 0.50
b. 6.00 ± 0.25
c. 5.75 ± 0.50
d. 6.25 ± 0.25
e. 5.75 ± 0.25

____ 2. In the laboratory, a student varies the concentrations of **A** & **B** in the reaction shown below while observing the absorbance of **G** (the only compound to absorb at the observed wavelength). Given the following data, determine the rate law for the reaction (recall that absorbance is directly proportional to concentration):

$$\mathbf{A + B \rightarrow G + H}$$

Trial 1: [A] = 0.5 mol•L^{-1} [B] = 0.5 mol•L^{-1}		Trial 2: [A] = 0.5 mol•L^{-1} [B] = 1.0 mol•L^{-1}		Trial 3: [A] = 1.0 mol•L^{-1} [B] = 0.5 mol•L^{-1}	
Time (s)	Absorbance	Time (s)	Absorbance	Time (s)	Absorbance
30	0.3	30	0.6	30	0.3
60	0.4	60	1.0	60	0.4
90	0.5	90	1.4	90	0.5
120	0.6	120	1.8	120	0.6

a. $v_0 = k[A]^1[B]^1$

b. $v_0 = k[A]^2[B]^1$

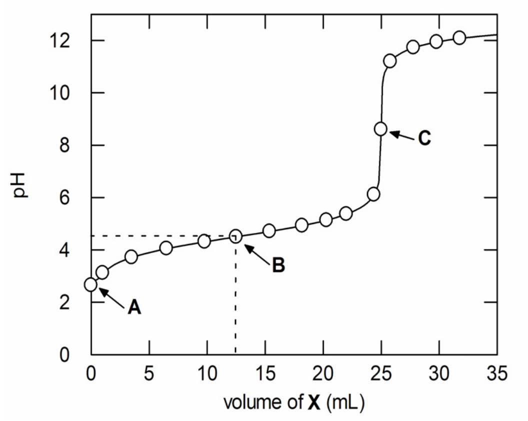
c. $v_0 = k[A]^2[B]^0$

d. $v_0 = k[A]^1[B]^2$

e. $v_0 = k[A]^0[B]^2$

Continued on next page...

____ 3. Both the acid and base used to generate the titration plot below are monoprotic. The concentration of the solution being added, **X**, is 0.500 M. You start with a solution of **Y** at point A. Determine which of the following statements is/are **true**:



i. The K_a of the acid is approximately 4.5.
ii. The effective buffer region can be described when 2.5 mL to 22.5 mL of **X** has been added.
iii. An appropriate indicator would be Thymol blue (K_{In} = 1.26 x 10^{-9}).
iv. Approximately 0.250 moles of acid were present at the beginning of this titration.
v. This graph represents the titration of a weak acid with a strong base.

a. i, ii, iii, v
b. i, iii
c. ii, iii, v
d. v
e. ii, iv v

____ 4. Which of the following indicators could you use to distinguish between a beaker containing 1.50 M acetic acid (K_a = 1.8 x 10^{-5}) and a beaker containing 0.0025 M phenol (K_a = 1.1 x 10^{-10})?

i. Methyl red K_{In} = 1.12 x 10^{-5}

ii. Methyl orange K_{In} = 3.98 x 10^{-4}

iii. Crystal violet K_{In} = 1.3 x 10^{-1}

iv. Cresol red K_{In} = 8.7 x 10^{-9}

a. i, iv
b. iv
c. ii
d. i, ii
e. ii, iii

____ 5. Benzoic acid (8.50 g, K_a = 6.5 x 10^{-5}) and 9.50g of sodium benzoate are dissolved in water to a final volume of 250.0 mL. The pH of this solution is:

a. 9.21
b. 3.18
c. 5.73
d. 4.05
e. 4.16

Continued on next page...

____ 6. A 100. mL solution of diethylamine (K_b = 1.3 x 10^{-3}) was titrated with 0.0150 M HCl. The equivalence point was reached when 180. mL of acid had been added. What was the concentration of the base in the original solution, and what is the pH at the equivalence point?

a. 0.270 M; pH = 8.21
b. 0.0270 M; pH = 6.12
c. 0.0400 M; pH = 4.31
d. 0.0400 M; pH = 5.24
e. 0.0270 M; pH = 6.56

____ 7. Which statement is incorrect about the titration in which 0.10 M HCl is added to 25.0 mL of 0.10 M NH_3 (K_b = 1.8 x 10^{-5})?

a. An indicator with pK_{HIn} = 5.3 could be used for this titration.
b. The initial pH is greater than 7.0.
c. The equivalence point is when 25.0 mL of HCl has been added.
d. The pH at the equivalence point is greater than 7.0.
e. A buffer is created before reaching the equivalence point.

____ 8. A reaction has an activation energy of 42.6 kJ/mol and a rate constant of 0.045 s^{-1} at 25.0°C. At what temperature will the reaction rate quadruple?

a. 74.2°C
b. 121.5°C
c. 51.1°C
d. 32.7°C
e. 65.3°C

Continued on next page...

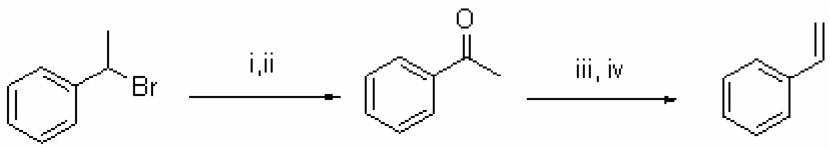
____ 9. Consider the following mechanism for the catalyzed decomposition of ozone to form oxygen gas ($2O_3 \rightarrow 3O_2$):

$O_3 + NO \rightarrow NO_2 + O_2$
$O_3 + O_2 \rightarrow 2\ O_2 + O$
$NO_2 + O \rightarrow NO + O_2$

Which of the following statements about this reaction is true?

a. O_3 is a catalyst and O_2 is an intermediate
b. O and NO are catalysts while NO_2 is an intermediate
c. NO_2 is a catalyst and NO is an intermediate
d. NO and NO_2 are catalysts while O is an intermediate
e. NO is a catalyst and NO_2 is an intermediate

____ 10. Which is the correct combination of reagents to accomplish the following synthesis? Note that not all products are shown ((dil) = dilute aqueous solution).



a. (i) KOH (dil) (ii) PCC (iii) 1. $NaBH_4$, 2. H_3O^+ (iv) $KMnO_4$
b. (i) NaOH (dil) (ii) $KMnO_4$ (iii) 1. $NaBH_4$, 2. H_3O^+ (iv) H_2SO_4 (conc)
c. (i) H_2SO_4 (dil) (ii) $K_2Cr_2O_7$ (iii) 1. $NaBH_4$, 2. H_3O^+ (iv) H_2SO_4 (dil)
d. (i) H_2SO_4 (dil) (ii) $K_2Cr_2O_7$ (iii) PCC (iv) H_2SO_4 (conc)
e. (i) H_2SO_4(conc)(ii) $K_2Cr_2O_7$(iii) PCC (iv) H_2SO_4 (dil)

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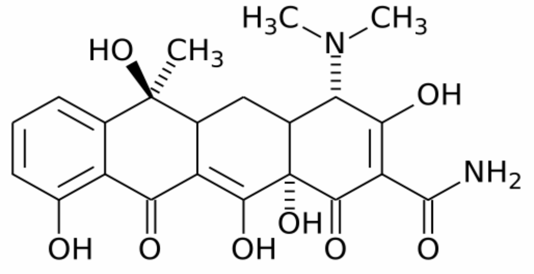
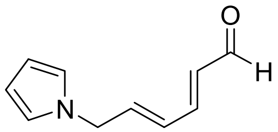
____ 11. Which functional groups are present in tetracycline, shown below?



a. phenol, amide, ketone
b. aryl ring, aldehyde, amine
c. primary alcohol, amine, amide
d. amide, ester, tertiary alcohol
e. ester, amide, ketone

____ 12. How many sigma-bonds, pi-bonds, sp^2- and sp^3-hybridized atoms are there in the following molecule?



σ-bonds	π-bonds	sp^2-hybridized atoms	sp^3-hybridized atoms
a. 13	6	10	2
b. 24	6	10	2
c. 23	5	11	1
d. 20	5	9	3
e. 23	4	9	1

Continued on next page...

____ 13. Which of the following statements regarding carbocations is <u>not</u> true?

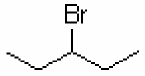
a. Alkyl substituents stabilize the positive charge in carbocations by being electron donating.

b. Hydration of 2-methyl-2-pentene in dilute aqueous acid yields 2-methylpentan-2-ol.

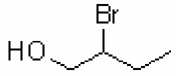
c. The neopentane cation (2,2-dimethylpropyl cation) is more stable than a secondary alkyl cation.

d. Loss of the halide leaving group from a tertiary alkyl halide relieves steric hindrance, which helps to stabilize the carbocation.

e. Compound **1** is likely to undergo S_N1 nucleophilic substitution more quickly than compound **2**.



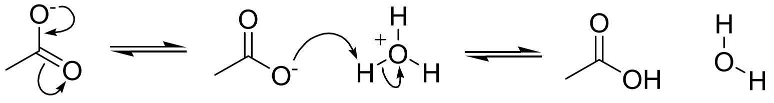
1



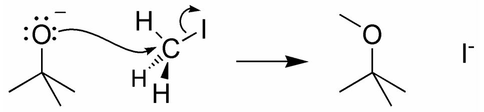
2

____ 14. In which of the following figures are <u>all</u> the arrows used correctly?

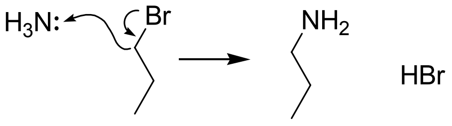
a.



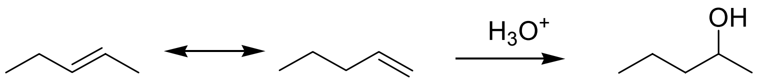
b.



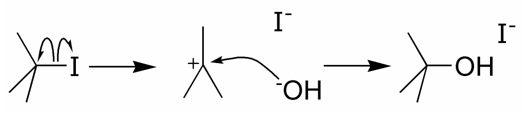
c.



d.



e.



____ 15. The synthesis of ammonia in the Haber process is accelerated by a solid catalyst based on iron oxide (rust) particles. The reaction is exothermic.

$$N_2(g) + 3\,H_2(g) \xrightleftharpoons{\text{iron oxide catalyst}} 2\,NH_3(g)$$

If a reaction is modified simply by grinding the catalyst into much smaller particles, with reactant concentrations and pressures held constant, which of the following statements is <u>not true</u>?

a. The reaction rate will increase.

b. More heat will be generated per second.

c. The equilibrium constant will favour more NH_3 formation.

d. $v = -{}^{1}/_{3} \times d[H_2]/dt$

e. The reaction requires one or both reactants to adsorb on the surface of the catalyst.

____ 16. Given the following experimental data for the reduction of nitric oxide with hydrogen gas, which includes initial concentrations and rates, determine the rate law.

Experiment	[NO]	$[H_2]$	Rate
1	6.4×10^{-3} M	2.2×10^{-3} M	2.6×10^{-5} M/s
2	12.8 mM	2.2×10^{-3} M	0.104 mM/s
3	6.4 mM	4.5×10^{-3} M	5.1×10^{-5} M/s

a. $v = k[NO]^2$
b. $v = k[NO]^2[H_2]$
c. $v = k[NO][H_2]$
d. $v = k[NO_2]^2[H_2]$
e. $v = k[HNO_2]^2[H_2]$

____ 17. Oxalyl chloride $(COCl)_2$ decomposes at 200°C to give carbon monoxide and chlorine gas via a first order process ($k = 2.2 \times 10^{-5}\ s^{-1}$). What is the final concentration of a 0.0248 M solution of oxalyl chloride after a reaction is allowed to proceed at 4.5 hours at 200°C, and what is the hybridization of the carbon atoms in the starting material?

	$[(COCl)_2]$	Hybridization
a.	0.034 M	sp^2
b.	17 mM	sp^3
c.	0.17 M	sp^2
d.	0.034 M	sp
e.	17 mM	sp^2

____ 18. A redox reaction of technetium-99m, the most widely used radionuclide in diagnostic medicine, occurs via a first order process with a rate constant of $2.0 \times 10^{-6}\ s^{-1}$. How long would it take the reaction to reach 90% completion?

a. 13.3 days
b. 3.5 s
c. Not enough information to answer the question.
d. 3.2 hours
e. 32 minutes

____ 19. A 1mM solution of 2-phenylethanol was heated at 500°C for 155 s. The final concentration was 0.00067 M. What would the final concentration be if the sample were heated at 500 °C for 4.27 min in total, assuming the reaction is first order?

a. 5.2×10^{-4} M
b. 6.8×10^{-4} M
c. 52 M
d. 2.25 mM
e. Not enough information to answer the question.

Continued on next page...

____ 20. In the gas phase, oxidation of nitric oxide (NO) with ozone (O_3) produces nitrogen dioxide and oxygen. The activation energy for the forward reaction is 10 kJ mol^{-1}, and it is 210 kJ mol^{-1} for the reverse reaction. Which of the following statements is true ?

a. The lifetime of the key intermediate is shorter than that of the preceding transition state.

b. ΔH = -200 kJ mol^{-1} in the forward reaction, and the reaction is exothermic.

c. The reaction is not likely to proceed, as both ΔH and ΔS are unfavourable.

d. The stoichiometry of the chemical reaction gives the overall reaction order.

e. The products are less stable than the reactants.

Continued on next page...

____ 21. Heating cyclopropane results in the formation of propene via a two step process. In the proposed mechanism, the first elementary process, which is slow, involves two molecules of cyclopropane associating to form an intermediate. The breakdown of this intermediate is fast and involves the loss of a proton, ultimately leading to the formation of propene. Which of the following statements is/are true?

i. $v_o = k[C_3H_6]^2$

ii. The reaction is likely exothermic because of changes in bond angles and eclipsing interactions.

iii. In the most favourable conformation of cyclopropane, the Newman projection reveals gauche interactions looking down each carbon-carbon bond.

iv. The half-life of the reaction is a constant and can be used to determine the reactant concentration at any time in the reaction.

v. This is an example of a reaction where, at low concentrations of the reactant cyclopropane, the reaction is likely first order, but at higher concentrations it becomes zeroth order.

a. i, iv, v
b. ii, iv
c. i, ii
d. ii, v
e. i, iii

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____ 22. For a typical reaction involving a homogenous catalyst, doubling the amount of the catalyst in a reaction will do which of the following?

a. Double the reaction rate.
b. There will be no change in the reaction rate.
c. Decrease the reaction rate because the concentration of the substrate [S] will be at the half-maximum value.
d. Quadruple the reaction rate
e. It will cause the activation energy to become zero and will establish a situation where $K_{eq} = 1$.

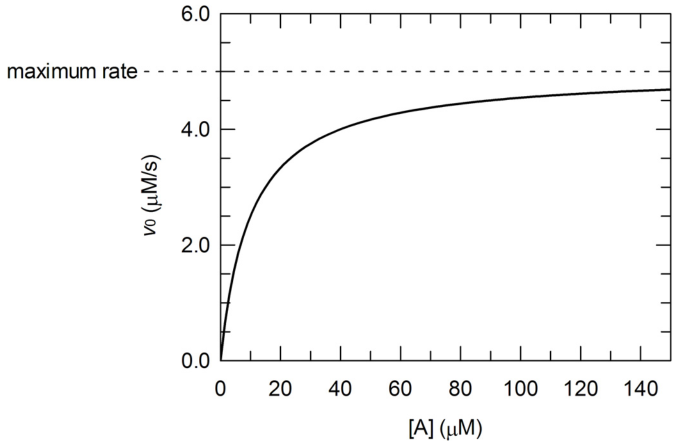
____ 23. Which of the following statements about enzyme kinetics is/are <u>true</u>?

i. At low [S], doubling the substrate concentration roughly doubles the rate.
ii. At high [S], reactions are pseudo-first order with respect to [S].
iii. The value of K_M (from the steady-state approximation) is approximately equal to K_s (from the equilibrium assumption) when $k_2 >> k_{-1}$.
iv. $[S]_{free} \approx [S]_{total}$ when t ≈ 0.
v. For the equilibrium assumption, if $[S] = K_s$ then $[E \bullet S] = 0$.

a. ii, v
b. i, iii
c. i, iv, v
d. i, iv
e. ii, iv

Continued on next page...

____ 24. An enzyme, E, catalyzes a reaction using substrate **A**. The curve of v_0 versus [**A**] shown below is obtained when $[E]_0 = 0.1\ \mu M$. What are the values of k_{cat} and K_M for this reaction?



	k_{cat}	K_M
a.	$5\ M^{-1}{\bullet}s^{-1}$	10 μM
b.	$50\ M^{-1}{\bullet}s^{-1}$	50 μM
c.	$50\ s^{-1}$	10 μM
d.	$5\ \mu M{\bullet}s^{-1}$	10 μM
e.	$5\ s^{-1}$	150 μM

____ 25. Increased intermolecular forces (IMF) lead to:

a. Increased melting point.

b. Decreased boiling point.

c. Increased molecular weight.

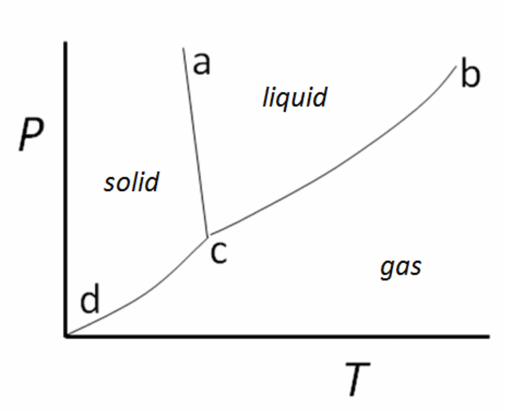
d. Decreased viscosity.

e. Increased vapour pressure.

____ 26. Place the following molecules in order from highest to lowest viscosity.

a. iii > v > ii > i > iv
b. iv > i > ii > v > iii
c. v > iv > ii > i > iii
d. iv > i > iii > ii > v
e. i > ii > iv > iii > v

____ 27. Indicate the <u>incorrect</u> statement about this phase diagram:



a. Along the line from **c** to **d**, solids can melt without evaporating.
b. At the point **c** all three phases can coexist.
c. The negative slope of the line from **a** to **c** indicates that the material expands upon freezing.
d. Along the line from **c** to **b**, the liquid and vapour phases are in equilibrium.
e. Point **b** indicates the critical point.

____ 28. Indicate the incorrect statement concerning the properties of matter at the critical point:

a. As temperature and pressure increases toward the critical point, the gas-liquid interface becomes more clearly distinguishable.

b. At the critical point, the solid phase of the material is not present.

c. The viscosity of supercritical fluids is between that of the corresponding gas and liquid.

d. The surface tension of the liquid becomes zero at the critical point.

e. The densities of liquid and vapour phase become identical at the critical point.

____ 29. Indicate the incorrect statement(s):

i. The triple point of water is the point in the phase diagram where ice can melt or sublime without input of energy.

ii. Critical point drying avoids phase boundaries and hence prevents structural collapse of fragile materials from capillary forces.

iii. IMFs affect phase transitions (solid to liquid; liquid to gas), as well as properties within condensed phases (solid, liquid) such as hardness and viscosity, but not typically properties in the vapour phase.

a. ii, iii
b. i, ii
c. ii
d. iii
e. i

____ 30. Indicate the incorrect statement regarding aromatic compounds

a. The number of delocalized *pi* electrons in an aromatic ring must be $4n+2$, where n is the number of atoms in the ring.

b. Aromatic compounds may contain carbon, nitrogen, oxygen and other hetero atoms in the aromatic ring.

c. Aromatic compounds must contain one or more planar rings with delocalized *pi* electrons.

d. Aromatic rings are inherently less reactive than analogous linear compounds.

e. Aromatic rings may be uncharged or carry a positive or negative charge.

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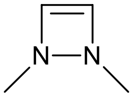
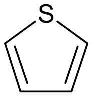
____ 31. Indicate which of the compounds below cannot be aromatic (you should consider all reasonable resonance forms):

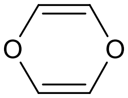
i



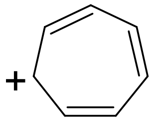
ii



iii



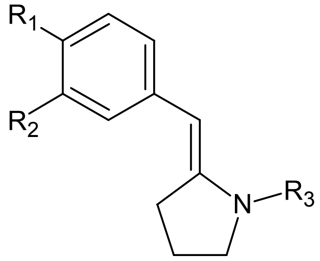
iv



v

a. v
b. ii
c. ii, iii
d. i, iv
e. iv

____ 32. Indicate the correct statement(s) regarding the library of dopamine analogs based on the molecular scaffold below where the R groups represent potential sites for varying the structure:



i. A library containing over 300 unique compounds may be constructed using seven different substituents at each site of diversity.

ii. If only R_1 and R_2 were available as sites of diversity, constructing a library of 320 molecules could be accomplished using 18 different substituents at each site.

iii. The double bond located between the two rings can be designed to be either *E* or *Z*, and hence serve as an additional site of diversity.

iv. Derivatization of the most basic site in this molecule could be done through reactions with electrophiles.

a. All are incorrect
b. All are correct
c. One is incorrect
d. Two are incorrect
e. Three are incorrect

Section #2 – These questions are worth three marks each.

____ 33. A 500.0 mL solution of a formic acid/sodium formate buffer is created, with a pH of 4.00. What is the minimum concentration of formate ion required in the buffer such that the addition of 100.0mL of 0.7853M HCl only changes the pH by 0.4 units? (K_a(HCOOH) = 1.8×10^{-4})

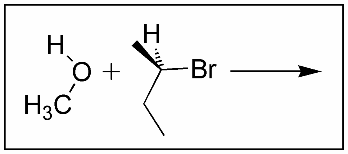
a. 0.140 M
b. 0.300 M
c. 0.125 M
d. 0.450 M
e. 0.350 M

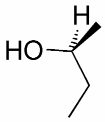
____ 34. Ethyl magnesium bromide (6.50 g) is reacted with 10.0g of carbon dioxide. After an hour, the solution is treated with an excess of dilute HCl. The desired organic product (100% yield) is isolated quantitatively and dissolved in 500.0 mL of water. To this solution, 0.840g of KOH is added. What is the pH of the final solution?
($K_a(CH_3COOH) = 1.8 \times 10^{-5}$; $K_a(CH_3CH_2COOH) = 1.3 \times 10^{-5}$)

a. 6.32
b. 4.79
c. 4.53
d. 5.26
e. 3.12

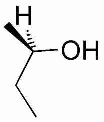
____ 35. Methanol reacts with *sec*-butyl bromide, as shown below. The reaction rates with varying methanol concentrations are also shown. What is/are the correct product(s)?

[MeOH] (M)	v_0 (M/min)
1.0	0.04
1.5	0.06
2.0	0.08

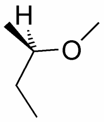




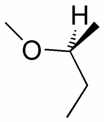
(*i*)



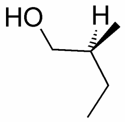
(*ii*)



(*iii*)



(*iv*)



(*v*)

a. *i*, *ii*
b. *v*
c. *iv*
d. *ii*
e. *iii*, *iv*

____ 36. An enzyme possesses a carboxylic acid functional group that must be in the protonated form (R-COOH) for the enzyme to have catalytic activity. In the deprotonated form ($R\text{-}COO^-$), it has no activity. If the carboxylic acid functional group has a pK_a value of 6.0, what will be the effect of changing the pH of the solution from 6.5 to 7.0?

a. The initial velocity will not change.
b. The initial velocity will decrease by a factor of 5.2.
c. The initial velocity will increase by a factor of 2.6.
d. The initial velocity will increase by a factor of 5.2.
e. The initial velocity will decrease by a factor of 2.6.

Continued on next page...

____ 37. The bonds in the backbone of DNA have a half-life of 140,000 years (4.4×10^{12} s). The concentration of these bonds in humans is 3×10^{-4} M, and the volume of the average person is 70 L. How many of these DNA backbone bonds break each second in the average person?

a. 2.0×10^{9} bonds/s
b. 1.3×10^{-9} bonds/s
c. 2.8×10^{7} bonds/s
d. 1.3×10^{8} bonds/s
e. 2.8×10^{-8} bonds/s

Continued on next page...

ROUGH WORK

Continued on next page...

Some general data are provided on this page and the next page. Other data appear with the questions.

A periodic table is provided on the next page.

STP = 273.15 K, 1 atm

R = 8.3145 J/K·mol = 0.08206 L·atm/K·mol

1 atm = 760 mm Hg = 101.325 kPa

1 J = 1 kg m^2 s^{-2} = 1 kPa·L = 1 Pa·m^3

1 cm^3 = 1 mL

F = 96485 C/mol

$N_A = 6.022 \times 10^{23}$ mol^{-1}

0°C = 273.15 K

1 m = 10^9 nm = 10^{10} Å

1 g = 10^3 mg

$K_w = 1.0 \times 10^{-14}$

$$\text{average rate} = -\frac{1}{a}\frac{\Delta[\mathrm{A}]}{\Delta \mathrm{t}} = \ldots = \frac{1}{g}\frac{\Delta[\mathrm{G}]}{\Delta \mathrm{t}} \ldots$$

$$v = \lim_{t \to 0} \frac{1}{g}\frac{\Delta[\mathrm{G}]}{\Delta \mathrm{t}} = \frac{1}{g}\frac{d[\mathrm{G}]}{dt}$$

$$v_0 = k[\mathrm{A}]^m[\mathrm{B}]^n$$

$$ln\frac{[\mathrm{A}]_t}{[\mathrm{A}]_0} = -kt$$

$$[\mathrm{A}]_t = [\mathrm{A}]_0 \bullet e^{-kt}$$

$$t_{1/2} = \frac{ln 2}{k} = \frac{0.69}{k}$$

$$[\mathrm{A}]_t = [\mathrm{A}]_0 - kt$$

$$v_0 = k[\mathrm{A}]^2 \text{ or } k[\mathrm{A}][\mathrm{B}]$$

$$\frac{d[\mathrm{E} \bullet \mathrm{S}]}{dt} = 0$$

$$v_0 = \frac{k_{cat}[\mathrm{E}]_0[\mathrm{S}]}{K_M + [\mathrm{S}]}$$

$$k = \mathrm{A}e^{-\mathrm{E_a}/\mathrm{RT}}$$

$$ln\frac{k_2}{k_1} = \frac{\mathrm{E_a}}{R}\left(\frac{1}{\mathrm{T_1}} - \frac{1}{\mathrm{T_2}}\right)$$

Student Name: ______________________ **Student No:** ________________________

PERIODIC TABLE OF THE ELEMENTS

ALDRICH®

Transition Metals (groups 3–12)

I 1	II 2	3	4	5	6	7	8	9	10	11	12	III 13	IV 14	V 15	VI 16	VII 17	VIII 18
1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.066	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.88	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.933	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** [98]	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 105.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57 ***La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** [209]	85 **At** [210]	86 **Rn** [222]
87 **Fr** [223]	88 **Ra** 226.03	89 ****Ac** 227.03	104 **Unq** [261]	105 **Unp** [262]	106 **Unh** [263]												

Atomic weights are based on $^{12}C = 12$ and conform to the 1987 IUPAC report values rounded to 5 significant digits.
Numbers in [ ] indicate the most stable isotope.

*** Lanthanides**	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
**** Actinides**	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** [244]	95 **Am** [243]	96 **Cm** [247]	97 **Bk** [247]	98 **Cf** [251]	99 **Es** [252]	100 **Fm** [257]	101 **Md** [258]	102 **No** [259]	103 **Lr** [262]