Name: _____ Student number: _____

**Chemistry 1AA3** **Final Exam** **April 13, 2009**

**McMaster University** **VERSION 1**

Instructors: P. Berti, P. Lock, J. Valliant

Duration: 3 hours

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This test contains 32 numbered pages printed on both sides. There are **37** multiple-choice questions appearing on pages numbered 3 to 27. Page 31 includes some useful data. There is a periodic table on page 32. Pages 28-30 may be used for rough work. You may tear off the last pages 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 28 are each worth 2 marks; questions 29 – 37 are each worth 3 marks. The total marks available are 83. There is **no** additional penalty for incorrect answers.

**BE SURE TO ENTER THE CORRECT VERSION NUMBER 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.

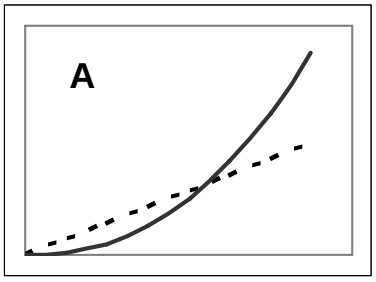
Name: _____ Student number: _____

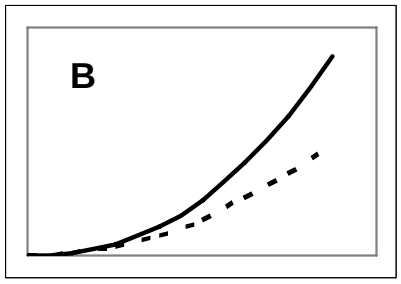
1. **You are writing VERSION 1 of this exam. Make sure you have correctly entered your version number ("1") in the correct column on your scan sheet (see p. 2 for details).**

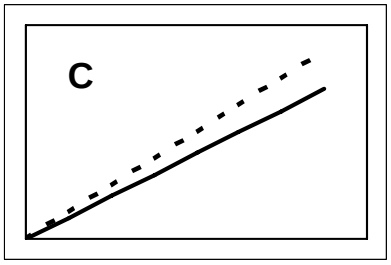
**Questions 1 through 28 are worth two (2) marks each.**

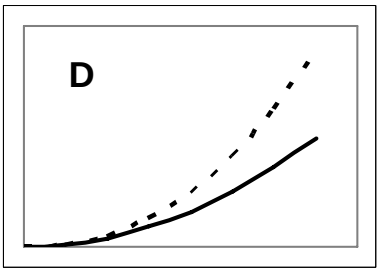
1. Which of the following graphs would **best represent the vapour pressure (y-axis) versus temperature (x-axis**) plot for both ammonia ($NH_3$; boiling point = -33ºC) and Water ($H_2O$; boiling point = 100ºC).

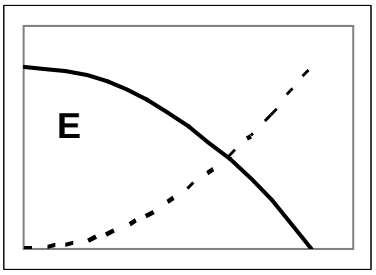
(------ Ammonia; ——— Water)



2. Arrange the following compounds

HF, $CO_2$, HCl, Ne and $H_2O$

in order of **decreasing** intermolecular forces (from strongest forces to weakest).

**(A)** HCl > $H_2O$ > HF > $CO_2$ > Ne

**(B)** $H_2O$ > HCl > HF > $CO_2$ > Ne

**(C)** $H_2O$ > HF > HCl > Ne > $CO_2$

**(D)** HF > $H_2O$ > HCl > Ne > $CO_2$

**(E)** $H_2O$ > HF > HCl > $CO_2$ > Ne

3. The **greatest change in energy** for a substance is seen with which of the following processes?

**(A)** vaporization

**(B)** condensation

**(C)** fusion

**(D)** sublimation

**(E)** melting

4. Each of the following compounds is a liquid at –50 °C.

(i) $H_3C-O-CH_3$ (ii) $CH_3CH_2CH_3$ (iii) $HOCH_2CH_2OH$

Place these liquids in order of **increasing vapour pressure** at a given temperature (from lowest vapour pressure to highest).

**(A)** i < ii < iii

**(B)** iii < ii < i

**(C)** i < iii < ii

**(D)** ii < i < iii

**(E)** iii < i < ii

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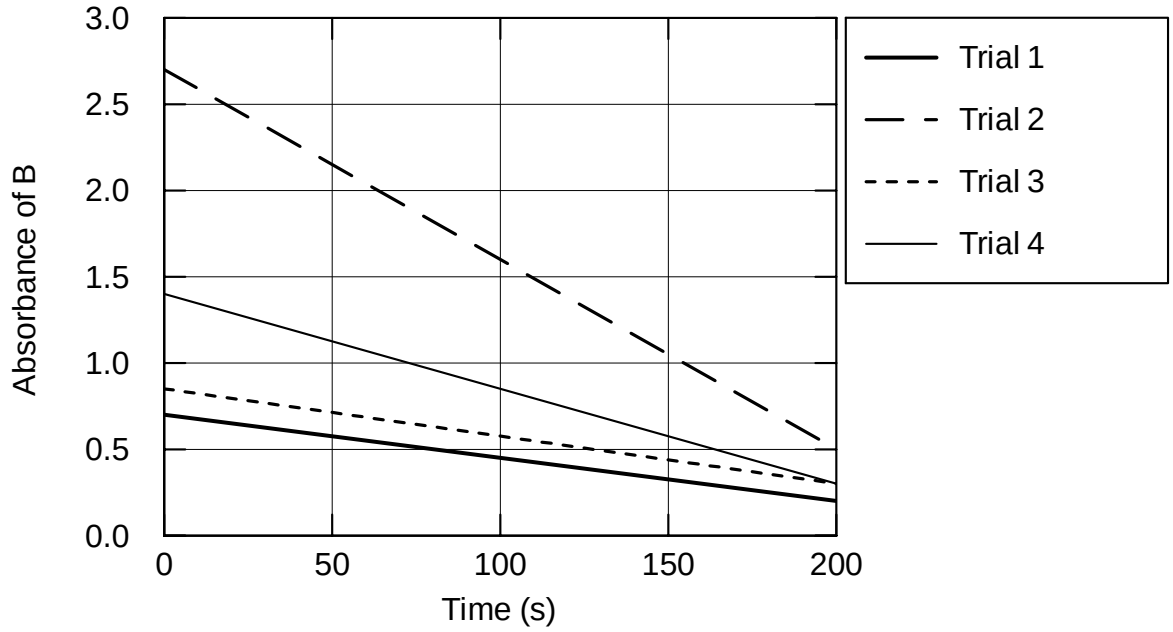
5. Given the following graph and data, determine the **rate law** for the following reaction

$$2A + B + C \rightarrow E + 3F$$

(Recall, absorbance is directly proportional to concentration)

| | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|
| [A] (M) | 0.2 | 0.4 | 0.2 | 0.2 |
| [B] (M) | 0.2 | 0.2 | 0.4 | 0.2 |
| [C] (M) | 0.2 | 0.2 | 0.2 | 0.4 |




**(A)** $v_0 = k[A]^2[B][C]$

**(B)** $v_0 = k[A]^2[B][C]^2$

**(C)** $v_0 = k[B][C]^2$

**(D)** $v_0 = k[A][B][C]$

**(E)** $v_0 = k[A]^2[C]$

6. In the chocolate unwrapping experiment in class, one student unwrapped foil-wrapped chocolates from a pile on the table (slow step), while a second student ate the unwrapped chocolates as quickly as possible (fast step). Which of the following statements is **FALSE**?

**(A)** Unwrapped chocolate is a reaction intermediate.

**(B)** [unwrapped chocolate] ≈ 0

**(C)** The rate-limiting step is unwrapping the chocolate.

**(D)** Doubling the number of people eating the chocolate would not change the overall rate of chocolate consumption.

**(E)** Doubling the number of chocolates in the pile would double the overall rate of chocolate consumption.

7. Which of the following statements about the Haber-Bosch reaction ($N_2 + 3H_2 \rightarrow 2NH_3$) must be **TRUE**?

**(A)** $3\ \Delta[H_2]/\Delta t = 2\ \Delta[NH_3]/\Delta t$

**(B)** $2\ \Delta[H_2]/\Delta t = 3\ \Delta[NH_3]/\Delta t$

**(C)** $v_0 = k[N_2][H_2]^3$

**(D)** $v_0 = -d[N_2]/dt$

**(E)** $v_0 = d[NH_3]^2/dt$

8. The reaction profile shown below is for the overall reaction:

$A + B + C \rightarrow G$

There are several steps in the reaction:

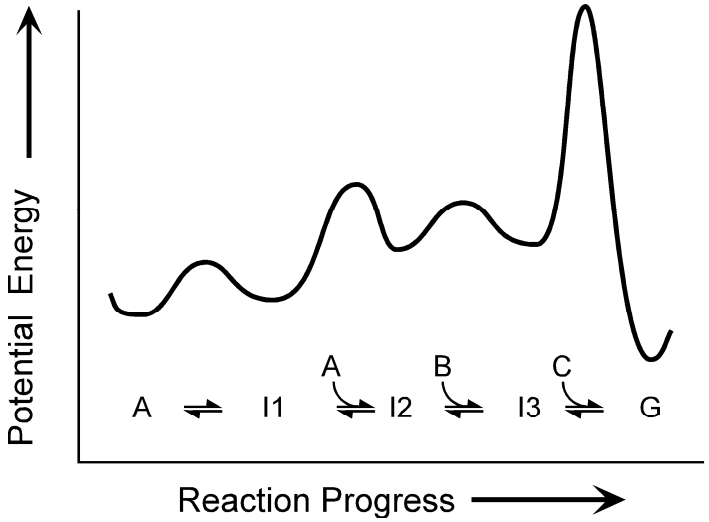
$A \rightleftharpoons I1$

$I1 + A \rightleftharpoons I2$

$I2 + B \rightleftharpoons I3$

$I3 + C \rightleftharpoons G$

What is the **overall rate equation** for this reaction?




**(A)** $v_0 = k[A]$

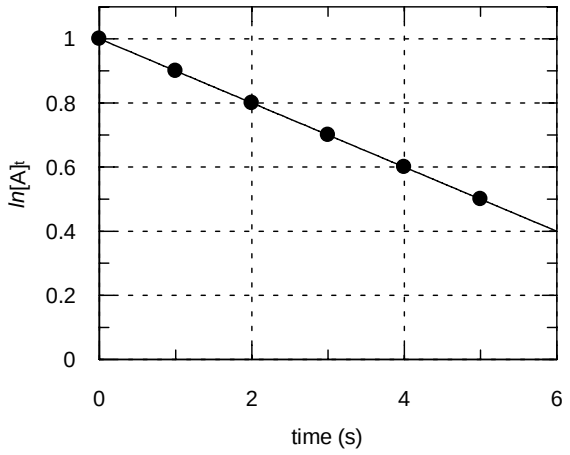
**(B)** $v_0 = k[A]^2[B]$

**(C)** $v_0 = k[A][B][C]$

**(D)** $v_0 = k[A]^2[B][C]$

**(E)** $v_0 = k[C]$

9. The graph below is for a first order reaction. What is the **value of *k***?




**(A)** -0.4 $s^{-1}$

**(B)** 0.4 $s^{-1}$

**(C)** 0.15 $s^{-1}$

**(D)** 0.1 $Ms^{-1}$

**(E)** 0.1 $s^{-1}$

10. The first hydrogen bomb was exploded in 1952, releasing tritium ($^3H$) into the atmosphere. The half-life for the radioactive decay of $^3H$ is $t_{1/2} = 3.9 \times 10^8$ $s^{-1}$. **What percentage** of the $^3H$ from the 1952 explosion has not yet decayed?

**(A)** $1.0 \times 10^{-4}$ %

**(B)** 0.0040 %

**(C)** 1.0 %

**(D)** 4.0%

**(E)** 10 %

11. For a reaction involving reactants A and B, the rate data in the table below were obtained. What is the **reaction rate** when [A] = 0.300 M and [B] = 0.400 M?

| Expt. # | [A] (M) | [B] (M) | d[A]/dt (M/s) |
|---|---|---|---|
| 1 | 0.20 | 0.30 | 0.24 |
| 2 | 0.40 | 0.60 | 1.92 |
| 3 | 0.20 | 0.60 | 0.48 |
| 4 | 0.40 | 0.30 | 0.96 |

**(A)** 0.56 M/s

**(B)** 0.72 M/s

**(C)** 0.28 M/s

**(D)** 1.4 M/s

**(E)** 0.68 M/s

12. In the following reaction, $\Delta[O_2]/\Delta t = -0.45$ M/s over the first 10 s of the reaction. What is the a**verage reaction rate in that time**?

$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$

**(A)** 0.09 M/s

**(B)** 0.09 $s^{-1}$

**(C)** –0.45 M/s

**(D)** 0.45 M/s

**(E)** 0.85 M/s

13. If $E_a = 48$ kJ•mol$^{-1}$ for a reaction, **at what temperature** would the reaction have to run in order to double the rate observed at 100 °C? (Assume A is constant).

**(A)** 106 °C

**(B)** 111 °C

**(C)** 117 °C

**(D)** 122 °C

**(E)** 128 °C

14. The activation energy for the decomposition of HI (g) into $H_2$ (g) and $I_2$ (g) at 300°C is 183 kJ•mol$^{-1}$. A metallic rhodium catalyst lowers the activation energy to 55 kJ•mol$^{-1}$. By **what factor would the reaction rate increase** in the presence of this catalyst? (Assume A is constant).

**(A)** 1.09

**(B)** $1.98 \times 10^{29}$

**(C)** $5.94 \times 10^{8}$

**(D)** $3.18 \times 10^{14}$

**(E)** $4.67 \times 10^{11}$

15. For the reaction: $2\ NO\ (g) + O_2\ (g) \rightarrow 2\ NO_2\ (g)$,

the rate doubles when the $O_2$ concentration is doubled, but it increases by a factor of 4 when the NO concentration is doubled. Which of the following mechanisms **is/are consistent with this**?

(i) $NO + O_2 \rightleftharpoons NO_3$ (fast)

$NO + NO_3 \rightarrow 2\ NO_2$ (slow)

(ii) $2\ NO \rightarrow N_2O_2$ (slow)

$O_2 + N_2O_2 \rightarrow N_2O_4$ (fast)

$N_2O_4 \rightarrow 2\ NO_2$ (fast)

(iii) $2\ NO \rightleftharpoons N_2O_2$ (fast)

$O_2 + N_2O_2 \rightarrow N_2O_4$ (slow)

$N_2O_4 \rightarrow 2\ NO_2$ (fast)

**(A)** i

**(B)** ii

**(C)** i, ii

**(D)** i, iii

**(E)** i, ii, iii

16. For a certain reaction, the rate constant, *k*, was measured at several temperatures. A plot of ln(*k*) vs. 1/T gave a straight line of the following form:

$$\ln(k) = -(8.15 \times 10^3)/T + 8.3$$

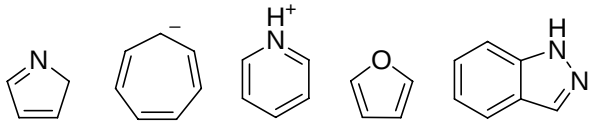
Calculate the activation energy, $\mathbf{E_a}$, in kJ•mol$^{-1}$, for the reaction.

**(A)** 3.85
**(B)** 22.0
**(C)** 50.1
**(D)** 67.8
**(E)** 244

17. A certain overall reaction occurs in two elementary steps. The first step has an activation energy, $E_a$, of 38 kJ•mol$^{-1}$ and is endothermic by 25 kJ•mol$^{-1}$. The overall forward reaction is exothermic by 11 kJ•mol$^{-1}$. If $E_a$ of the first step of the *reverse* reaction is 64 kJ•mol$^{-1}$, what is the **$E_a$ of the second step of the forward reaction**, in kJ•mol$^{-1}$?

**(A)** 6
**(B)** 28
**(C)** 37
**(D)** 53
**(E)** 62

18. Which of the following structures are **aromatic**? (You may assume that all compounds are planar if they meet all the other criteria for aromaticity.)



*i* *ii* *iii* *iv* *v*

**(A)** i, ii, iv

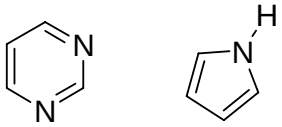
**(B)** ii, iv, v

**(C)** i, iii, v

**(D)** all structures

**(E)** iii, iv, v

19. What statement about pyrimidine (left) and/or pyrrole (right) is **<u>FALSE</u>**?



pyrimidine pyrrole

**(A)** Both compounds are aromatic.

**(B)** All nitrogen atoms are $sp^2$ hybridized.

**(C)** Pyrrole is a stronger base than pyrimidine.

**(D)** In pyrimidine, the orbitals containing the lone pairs of electrons are perpendicular to the π-system.

**(E)** The ion that results when pyrimidine is treated with HCl is aromatic.

20. A solution is created by adding 40. mL of 0.60 M NaOH to 1.0 L of 0.50 M $EtNH_2$ ($pK_b = 3.40$). What is the percent ionization of ethylamine in the solution?

**(A)** 1.7 %
**(B)** 7.8 %
**(C)** 12 %
**(D)** 0.031 %
**(E)** 3.5 %

21. If 100 mL of water is added to a 0.500 L solution containing 0.200 M ammonium nitrate and 0.200 M ammonia, what is the effect of dilution on the pH?

**(A)** The acidity decreases by a factor of 2.
**(B)** The pH of the solution will become neutral.
**(C)** There is no change in pH.
**(D)** The pOH will change but not the pH.
**(E)** None of the above is correct.

22. Which of the following mixtures is a buffer with pH close to 9?

($K_a$ $NH_4^+ = 5.6 \times 10^{-10}$)

**(A)** 50 mL of 0.1 M $NH_4Cl$ and 25 mL of 0.15 M NaOH

**(B)** 50 mL of 0.1 M $NH_3$ and 25 mL of 0.1M NaOH

**(C)** 50 mL of 0.1 M $NH_4Cl$ and 5 mL of 1.0M HCl

**(D)** 50 mL of 0.1 M $NH_4Cl$ and 25 mL of 0.1M HCl

**(E)** 25 mL of 0.1 M $NH_4Cl$ and 5 mL of 1M NaOH

23. A 25 mL solution of methylamine is titrated with 0.1009 M HCl and the equivalence point is reached at 25.57 mL of acid. (i) What is the **concentration of the methylamine stock solution**, and (ii) what is the **pH at the equivalence point**? The $K_a$ for the conjugate acid of methylamine is $2.4 \times 10^{-11}$.

**(A)** (i) 0.050 M (ii) 5.96

**(B)** (i) 0.10 M (ii) 5.96

**(C)** (i) 0.050 M (ii) 8.01

**(D)** (i) 0.025 M (ii) 8.01

**(E)** None of the above is correct

24. What is the **pH of the solution** that results when 0.300 mole of $CH_3COOH$, 0.250 mole of $CH_3COONa$ and 0.110 mole of NaOH are dissolved in sufficient water to produce 1.00 L of solution? ($K_a$ $CH_3COOH = 1.8 \times 10^{-5}$)

**(A)** 4.27

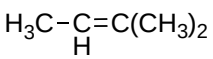
**(B)** 5.02

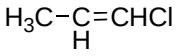
**(C)** 6.18

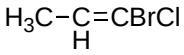
**(D)** 7.26

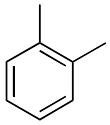
**(E)** 8.73

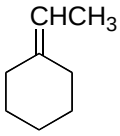
25. Which of the following compounds could undergo a **change of configuration about the double bond to form geometric isomers**?

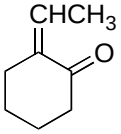
(i) 

(ii) 

(iii) 

(iv) 

(v) 

(vi) 

**(A)** ii, iii, vi

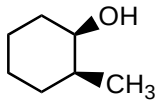
**(B)** ii, v

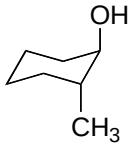
**(C)** i, iv, v

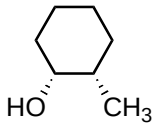
**(D)** iii, v

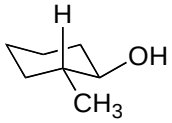
**(E)** i, vi

26. Which of the following structures **correctly represent(s)** the molecule *trans*-1-methyl-2-cyclohexanol?

(i) 


(ii) 


(iii) 


(iv) 


**(A)** i, iii

**(B)** ii, iv

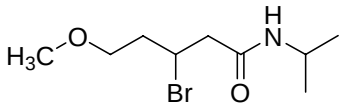
**(C)** ii

**(D)** i

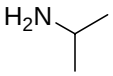
**(E)** iii, iv

Name: _____ Student number: _____

27. Which of the following precursors could **not** be used in the synthesis of compound **1**?



**1**

(*i*) $H_3C$-I (*ii*) $H_3C$-OH (*iii*) $H_3CMgBr$ (*iv*) HBr (*v*) 

**(A)** i

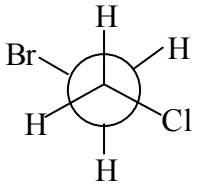
**(B)** ii

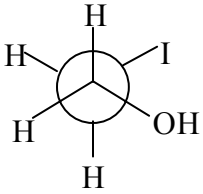
**(C)** iii

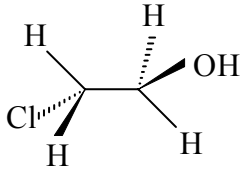
**(D)** iv

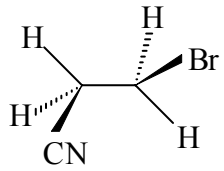
**(E)** v

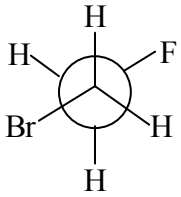
28. Which of the following molecules are shown in a ***gauche*** conformation?

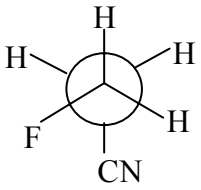
(i) 

(ii) 

(iii) 

(iv) 

(v) 

(vi) 

**(A)** i, iii, v

**(B)** ii, iv, vi

**(C)** i, v

**(D)** iii, iv

**(E)** i, iii, iv, v

**Questions 29 through 37 are worth three (3) marks each.**

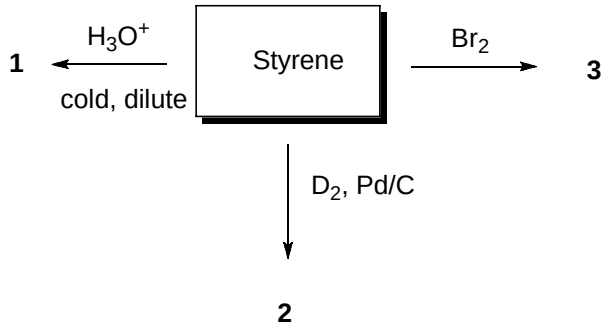
29. A sample containing toluene and bromine is accidentally left on the windowsill on a bright, sunny day. Which of the following statements are **FALSE**?

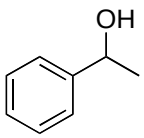
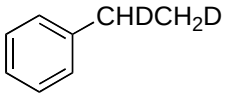
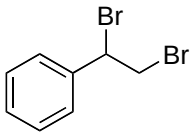
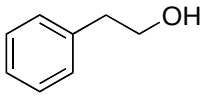
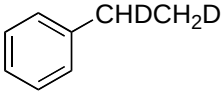
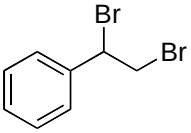
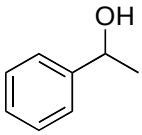
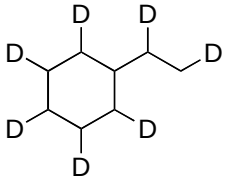
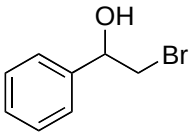
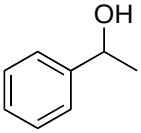
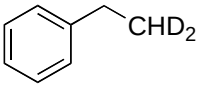
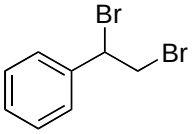
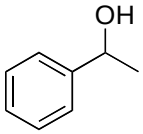
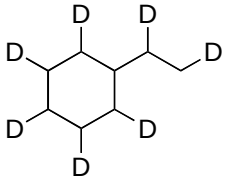
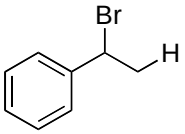
(i) Bromobenzene will be a reaction product.
(ii) The reaction will produce more than two products.
(iii) A reaction will occur whereby a bond between an s-orbital and a hybrid orbital is broken.
(iv) The reaction involves the transfer of electron pairs.
(v) The pH of the solution should decrease.

**(A)** i, iv
**(B)** i, ii
**(C)** ii, iii
**(D)** iii, v
**(E)** iv, v

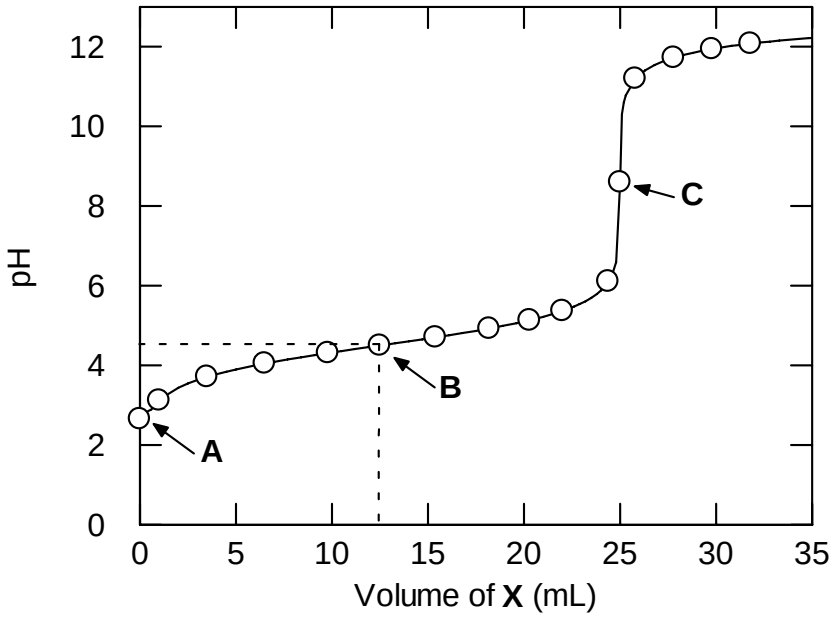
Name: _____ Student number: _____

30. Styrene (vinylbenzene) is a versatile starting material. What are the **correct structures** of the products **1**, **2** and **3**? (note: D = $^2$H, deuterium)




| | 1 | 2 | 3 |
|---|---|---|---|
| **(A)** |  |  |  |
| **(B)** |  |  |  |
| **(C)** |  |  |  |
| **(D)** |  |  |  |
| **(E)** |  |  |  |

31. Both the acid and the base in the titration plotted below are monoprotic. The concentration of the added solution, **X**, is 0.100 M. You start with a solution of **Y** at point **A**. Find the **FALSE** statements.




(i) The curve represents a strong acid – strong base titration.

(ii) Approximately 0.0025 moles of **Y** were present at the beginning of this titration (*point* **A**).

(iii) The p$K_a$ of **Y** is between 4.0 and 5.0.

(iv) The solution present at point **C** is a buffer.

(v) An appropriate indicator for this titration would be 2,4-dinitrophenol ($K_{HIn} = 1.3 \times 10^{-4}$).

**(A)** i, ii, iii

**(B)** i, v

**(C)** i, iv, v

**(D)** iii, v

**(E)** ii, iv

32. In the titration of 25.00 mL of 0.0940 M NaOH(aq) with HCl(aq) of unknown concentration, it was found that 16.30 mL of HCl were required to reach pH = 11.67. What is the **concentration (M) of the HCl(aq)** being titrated?

**(A)** 0.132 M
**(B)** 0.136 M
**(C)** 0.118 M
**(D)** 0.105 M
**(E)** 0.0968 M

33. Which of the following **indicators could be used** to distinguish a beaker containing a solution of 0.010 M HCOOH ($K_a = 1.8 \times 10^{-4}$) from a beaker of 0.0050 M HOCl ($K_a = 2.9 \times 10^{-8}$)?

| | Indicator | $K_{HIn}$ | colour change (acid → base) |
|---|---|---|---|
| (i) | Crystal violet | $1.3 \times 10^{-1}$ | yellow → blue |
| (ii) | Bromophenol blue | $1.4 \times 10^{-4}$ | yellow → blue |
| (iii) | Chlorphenol red | $1.0 \times 10^{-6}$ | yellow → red |
| (iv) | Bromthymol blue | $7.9 \times 10^{-8}$ | yellow → blue |

**(A)** i, ii
**(B)** iii, iv
**(C)** ii, iii
**(D)** ii
**(E)** iii

34. β-Lactamase is an enzyme that destroys penicillin-type antibiotics and makes bacteria antibiotic resistant. The steady state kinetic parameters with one particular β-lactamase were determined for several antibiotics.

(i) amoxicillin: $k_{cat} = 10\ s^{-1}$, $K_M = 2.0 \times 10^{-4}$ M

(ii) ampicillin: $k_{cat} = 30\ s^{-1}$, $K_M = 6.0 \times 10^{-4}$ M

(iii) penicillin G: $K_M = 1.0 \times 10^{-5}$ M, $v_0 = 1.6 \times 10^{-5}$ M/s when [β-lactamase] = 2 μM and [penicillin G] >> $K_M$

**Which antibiotic would be destroyed at the highest rate** if they were all present at a concentration of $1.0 \times 10^{-4}$ M?

**(A)** amoxicillin

**(B)** ampicillin

**(C)** penicillin G

**(D)** amoxicillin & ampicillin will be destroyed at the same rate

**(E)** all three antibiotics will be destroyed at the same rate

35. In the reaction of A to G, $k_1 = 12\ s^{-1}$ at 25 °C. The overall enthalpy of reaction, $\Delta H = 10\ kJ \cdot mol^{-1}$. What is the **rate constant for the reverse reaction, $k_{-1}$**?

$$A \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} G$$

**(A)** $0.012\ s^{-1}$

**(B)** $0.16\ s^{-1}$

**(C)** $0.21\ s^{-1}$

**(D)** $1.6\ s^{-1}$

**(E)** $21\ s^{-1}$

36. Reaction rate measurements show that reactions of $NH_3$ with *t*Bu-Br and *t*Bu-Cl are both $S_N1$ nucleophilic substitutions. $Br^-$ is known to be a better leaving group than $Cl^-$. Which of the following sets of data is/are **not consistent** with this?

(i)

| Expt #. | [$NH_3$] (M) | [*t*Bu-Br] (M) | [*t*Bu-Cl] (M) | $v_0$ (M/s) |
|---|---|---|---|---|
| 1 | 0.1 | 0 | 0.1 | 0.05 |
| 2 | 0.2 | 0 | 0.2 | 0.10 |

(ii)

| Expt #. | [$NH_3$] (M) | [*t*Bu-Br] (M) | [*t*Bu-Cl] (M) | $v_0$ (M/s) |
|---|---|---|---|---|
| 1 | 0.1 | 0 | 0.1 | 0.05 |
| 2 | 0.2 | 0.2 | 0.1 | 0.15 |

(iii)

| Expt #. | [$NH_3$] (M) | [*t*Bu-Br] (M) | [*t*Bu-Cl] (M) | $v_0$ (M/s) |
|---|---|---|---|---|
| 1 | 0.05 | 0.1 | 0 | 0.05 |
| 2 | 0.1 | 0 | 0.1 | 0.05 |

(iv)

| Expt #. | [$NH_3$] (M) | [*t*Bu-Br] (M) | [*t*Bu-Cl] (M) | $v_0$ (M/s) |
|---|---|---|---|---|
| 1 | 0.1 | 0 | 0.2 | 0.10 |
| 2 | 0.1 | 0.2 | 0 | 0.25 |

(v)

| Expt #. | [$NH_3$] (M) | [*t*Bu-Br] (M) | [*t*Bu-Cl] (M) | $v_0$ (M/s) |
|---|---|---|---|---|
| 1 | 0.1 | 0.1 | 0 | 0.05 |
| 2 | 0.2 | 0.1 | 0 | 0.05 |

**(A)** ii, iii, v

**(B)** ii, iii

**(C)** i, v

**(D)** i, ii, iii, v

**(E)** iv

37. Two unlabelled phase diagrams are shown below. Which one of the following statements is **FALSE** regarding the following pressure *versus* temperature phase diagrams?

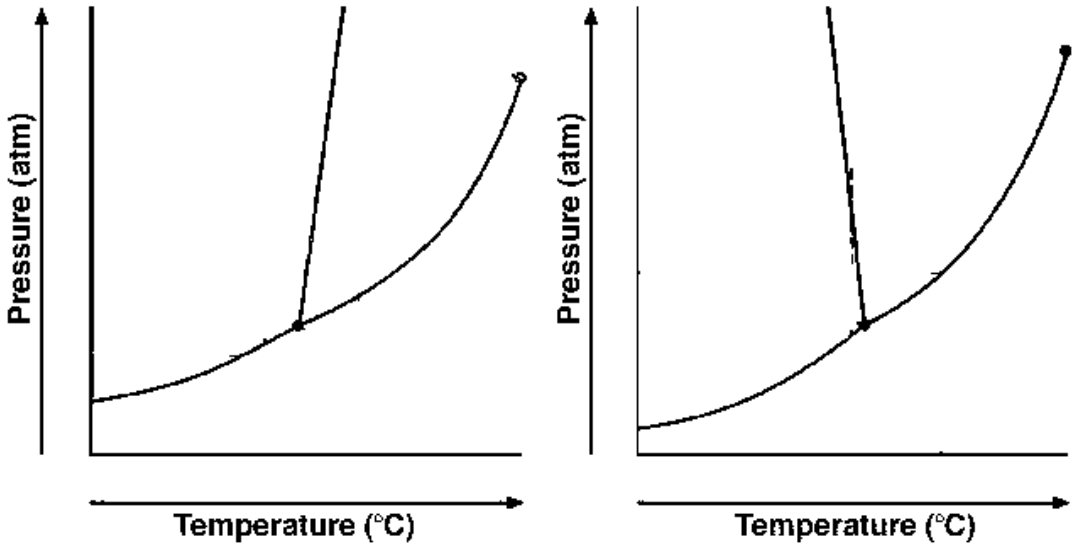
**(A)** The triple point temperature is always lower than the critical point temperature.

**(B)** There can be no liquid-gas phase equilibrium at pressures above the critical point pressure.

**(C)** Below the triple point pressure, decreasing pressure always decreases the sublimation temperature.

**(D)** Above the triple point pressure, increasing pressure always increases the melting temperature.

**(E)** Below the triple point pressure, cooling a gas sufficiently may result in deposition of the gas.



Name: _____ Student number: _____

Some general data are provided on this 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

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

| | |
|---|---|
| $\text{average rate} = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} = \ldots = \frac{1}{g}\frac{\Delta[G]}{\Delta t}\ldots$ | $v = \lim_{t \to 0} \frac{1}{g}\frac{\Delta[G]}{\Delta t} = \frac{1}{g}\frac{d[G]}{dt}$ |
| $v_0 = k[A]^m[B]^n$ | $ln\frac{[A]_t}{[A]_0} = -kt$ |
| $[A]_t = [A]_0 \bullet e^{-kt}$ | $t_{1/2} = \frac{ln\,2}{k} = \frac{0.69}{k}$ |
| $[A]_t = [A]_0 - kt$ | $v_0 = k[A]^2$ or $k[A][B]$ |
| $\frac{d[E \bullet S]}{dt} = 0$ | $v_0 = \frac{k_{cat}[E]_0[S]}{K_M + [S]}$ |
| $k = Ae^{-E_a/RT}$ | $ln\frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ |