Student Name: _____ Student No: _____

Chemistry 1AA3 **Final Exam** **April 12, 2013**

McMaster University **VERSION 1**

Instructors: D. Brock, J. Landry, P. Lock, H. Stöver

Duration: 180 min.

This test contains 26 numbered pages printed on both sides. There are 36 multiple-choice questions appearing on pages numbered 3 to 22. Pages 23 and 24 are extra space for rough work. Page 25 includes some useful data and equations. There is a periodic table on page 26. 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.

All questions are each worth 2 marks; the total marks available are 72. 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. Keep your eyes on your own paper - looking around the room may be interpreted as an attempt to copy.

Only Casio FX 991 MS 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.

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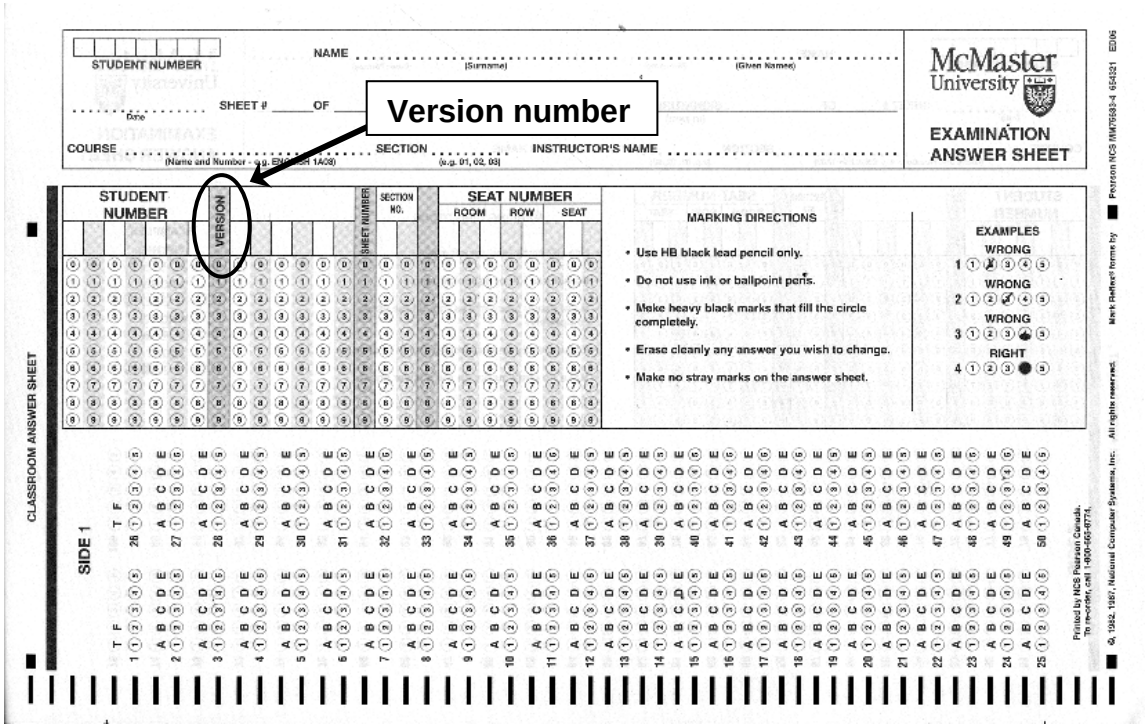
Student Name: _____ Student No: _____

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”.



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VERSION **1**.
Enter your version number in the correct column on your scan sheet (see p. 2 for details).

1. Which of the following statements about physical properties is **FALSE**?

   A) At 25°C propanone has a higher vapour pressure than propane.
   B) 1,5-Pentanediol has a higher viscosity than 1-butanol.
   C) Hydrogen bond stoichiometry predicts that the melting point of H_2O should be higher than those of either NH_3 or HF.
   D) HF has a higher boiling point than HCl.
   E) 2,2-Dimethylpropane has a lower boiling point than pentane.

2. A reaction with an activation energy of 50.2 kJ mol^{-1} has $k = 2.38 \times 10^{1}$ s^{-1} at 47°C and $k = 4.18 \times 10^{2}$ s^{-1} at another temperature. What is this other **temperature (°C)**?

   A) 85
   B) 63
   C) 104
   D) 78
   E) 92

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3. Which of the following are **conjugate bases of strong acids**?

i) HSO_4^-
ii) H_2O
iii) NH_2^-
iv) Cl^-
v) CH_3COO^-

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

4. Which of the following statements about kinetics is **FALSE**?

A) A graph of [reactant] vs. time for a first-order reaction shows a decay curve with constant half-life.
B) A graph of ln *k* vs. 1/T gives a straight line with a negative slope.
C) A graph of [product] vs. time for a zero-order reaction gives a straight line with a positive slope (until all reactant is consumed).
D) A graph of [reactant] vs. time for a zero order reaction gives a horizontal line.
E) Graphing ln [reactant] vs. time for a first-order reaction gives a straight line with a negative slope

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5. The isotope ^{131}I can be used to measure the activity of the thyroid gland. Given that a certain amount of potassium iodide containing ^{131}I undergoes radioactive decay at a rate of 2.15×10^5 disintegrations per minute initially, and 6.43×10^4 disintegrations per minute after 2 weeks, calculate the **half-life (days) of ^{131}I**.

   A) 9.70 days
   B) 8.04 days
   C) 4.02 days
   D) 14.0 days
   E) 18.5 days

6. Formic acid (HCOOH, 50.0 mL, 0.100 M) is titrated with KOH(aq) (buret, 0.160 M). What is the **pH at the equivalence point** of the titration?

   Data: $K_a = 1.8 \times 10^{-4}$

   A) 9.02
   B) 7.66
   C) 9.81
   D) 10.13
   E) 8.27

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7. For the reaction $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$ the rate of disappearance of $H_2(g)$ is 0.18 M s^{-1}. What is the **rate of appearance (M s^{-1}) of $NH_3(g)$**?

   A) 0.12
   B) 0.090
   C) 0.060
   D) 0.36
   E) 0.54

8. Which one of the following mixtures **will result** in the formation of a **buffer**? (All solutions are 1.0 M).

   A) 40 mL KF and 40 mL HCl
   B) 80 mL CH_3COONa and 5 mL HCl
   C) 50 mL NaCl and 75 mL HCl
   D) 50 mL CH_3COOH and 60 mL KOH
   E) 40 mL HCOOH and 35 mL NaOH

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9. Indicate the **FALSE** statement below regarding reaction progress diagrams.

   A) A reaction intermediate is produced in one elementary step and consumed in a subsequent step.
   B) A mechanism with three elementary steps will have two reaction intermediates and three transition states.
   C) The ΔH for an elementary step can be determined by taking E_a(forward) – E_a(reverse) for that step.
   D) Once the transition state of a given step is reached the step must proceed towards completion.
   E) A catalyst will lower the activation energy of a reaction in both its forward and reverse directions.

10. Rank the following substances in terms of **increasing boiling point** (from lowest to highest boiling point):

    (i) *E*-2-pentene (ii) pentanol (iii) pentanal (iv) pentanoic acid

    A) i < iii < iv < ii
    B) iv < iii < i < ii
    C) i < ii < iii < iv
    D) i < iii < ii < iv
    E) iii < i < iv < ii

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11. For the reaction A $\rightarrow$ C, which of the following statements is **FALSE**, given the mechanism below?

$A \rightleftharpoons B$ k_1, forward; k_{-1}, reverse

$B \rightarrow C$ k_2 forward

A) If $k_2 >> k_1$ and $k_{-1} \approx 0$ then $v_o = k_1[A]$.
B) If the magnitudes of k_1, k_{-1} and k_2 are unknown, then a reasonable starting assumption for the rate law is $v_o = k_2[B]$.
C) According to the steady state approximation, d[B]/dt = 0.
D) If k_2 is rate-limiting then $v_o = k_1k_2[A]$.
E) If $k_1 >> k_2$ and $k_{-1} >> k_2$, then k_2 is rate-limiting.

12. Indicate the **INCORRECT** statement regarding radical halogenation of alkanes:

A) Radical halogenation involves propagation steps leading to formation of haloalkanes and hydrogen halide.
B) Chlorination of methane can produce chloromethane, dichloromethane and trichloromethane.
C) Light or heat can be used to cleave chlorine-chlorine bonds, generating free chlorine radicals.
D) Radical fluorination of alkanes is a very vigorous reaction, while radical iodination is not feasible.
E) Some ethane is formed as side product during halogenation of methane, and similarly, some methane is formed during halogenation of ethane.

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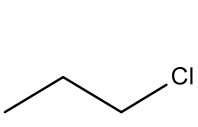
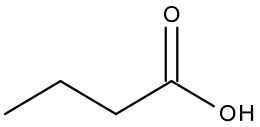
13. Which **reagents** would you use when converting Molecule 1 into Molecule 2?



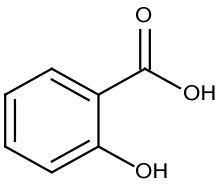
Molecule 1



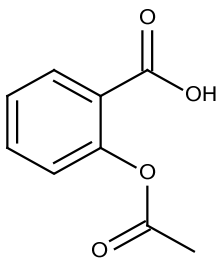
Molecule 2

	Step 1	Step 2
A)	Mg, Et_2O	dilute H_2SO_4
B)	H_2O	$K_2Cr_2O_7$
C)	NaOH	$KMnO_4$
D)	NaOH	i) CO_2, ii) dilute H_2SO_4
E)	Mg, Et_2O	i) CO_2, ii) dilute H_2SO_4

14. A student starts with 2.04 g salicylic acid (**1**) and prepares 2.27 g of wet acetylsalicylic acid (**2**). This wet product is then dried giving a 76% yield. **How much wate**r was in the wet sample of **2**?



1



2

A) 0.93 g
B) 0.18 g
C) 0.44 g
D) 0.25 g
E) 0.11 g

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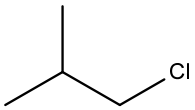
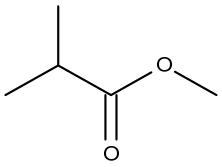
15. Which of the following reagents would **NOT** be used when converting Molecule 1 into Molecule 2?



Molecule 1

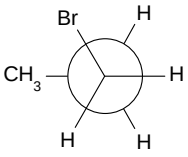


Molecule 2

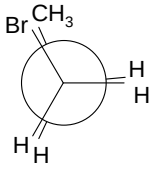
A) $NaBH_4$
B) NaOH
C) CH_3OH
D) $KMnO_4$
E) H_2SO_4

16. Which of the following projections would show the **second-highest energy conformation** looking along the C1-C2 bond of 1-bromopropane?

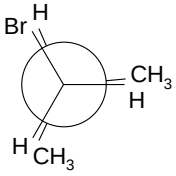
(A)



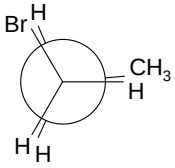
(B)



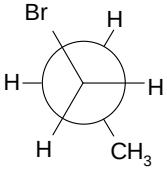
(C)



(D)



(E)



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17. You are given solutions of chemicals with the following molecular formulas. Which one of the following would you expect to react with $NaHCO_3$, **resulting in a visible change**?

A) CH_2O
B) C_2H_4
C) CH_4O
D) $C_2H_6O_2$
E) CH_2O_2

18. How many **isomers** (structural and geometrical) can be drawn for C_3H_5Cl?

A) 6
B) 5
C) 3
D) 2
E) 4

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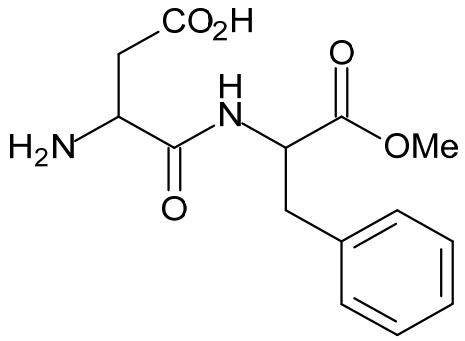
19. Indicate the **total number of carbon-oxygen sigma bonds plus carbon-nitrogen sigma bonds** in aspartame (shown below):



A) 11
B) 15
C) 13
D) 9
E) 7

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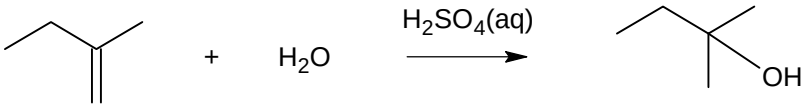
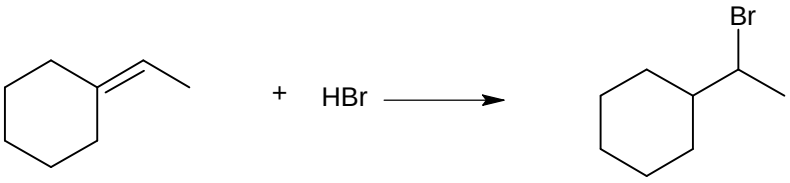
20. Which of the following reactions is **incorrect** as shown?

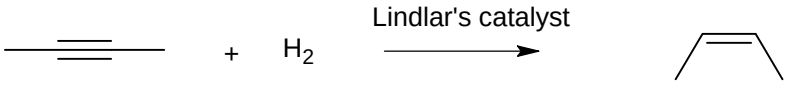
A)



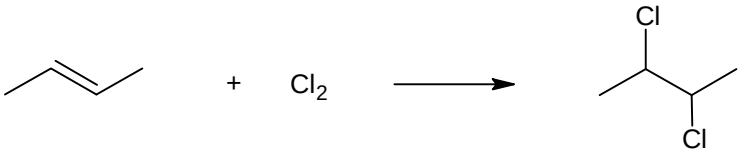
B)



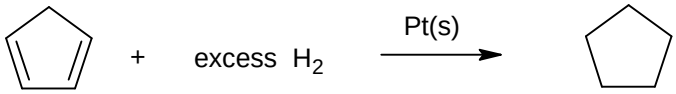
C)



D)



E)



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21. Identify the **FALSE** statement pertaining to S_N1 and S_N2 mechanisms:

    A) In the reaction of OH^- with $ClCH_2CH_2CH_3$, there is no carbocation intermediate.
    B) An S_N1 substitution occurs in more than 1 step.
    C) An S_N1 substitution will result in inversion and retention of configuration (stereochemistry).
    D) In the reaction of H_2O with $ClC(CH_3)_3$, increasing the concentration of $ClC(CH_3)_3$ will not increase the rate of reaction.
    E) An S_N2 reaction will result in an inversion of configuration (stereochemistry).

22. Identify the **FALSE** statement regarding the oxidation/reduction of organic molecules:

    A) Oxidation of alcohols is usually done under acidic or basic conditions to facilitate electron transfer.
    B) Reaction of a ketone with a Grignard reagent in ether, followed by dilute acid work-up, produces a tertiary alcohol.
    C) All alcohols can be oxidized to form one of an aldehyde, ketone, or carboxylic acid.
    D) PCC will not oxidize an aldehyde to a carboxylic acid.
    E) Reaction of an aldehyde with $NaBH_4$, followed by dilute acid work-up, will reduce the aldehyde to a primary alcohol.

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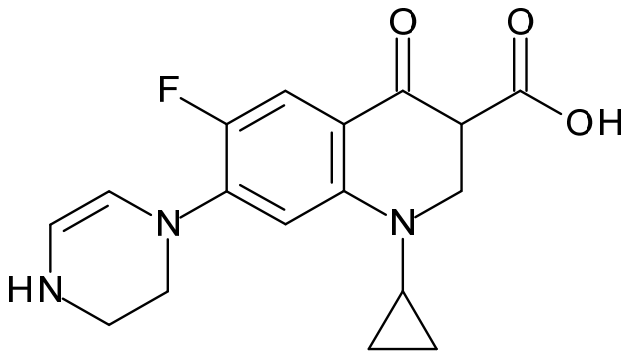
23. Identify the **correct list of functional groups** found in the Ciprofloxacin analog (antibiotic) shown below:



A) alkene, amide, aryl halide, carboxylic acid, ester
B) alkene, amine, aryl halide, carboxylic acid, ketone
C) ketone, alkyne, amine, carboxylic acid, aldehyde
D) alkene, amide, aryl halide, ester, ketone
E) alcohol, amide, amine, aryl halide, carboxylic acid, ketone

24. Which of the following statements about bonding and orbitals is **FALSE**?

A) In ammonia the lone pair of electrons is in an sp^3-hybridized orbital.
B) A π (pi) bond can be formed between an H atom and a C atom.
C) The methyl carbocation is sp^2-hybridized at C.
D) The C-C sigma bond in ethyne is formed by the overlap of sp hybrid orbitals.
E) The energy of sp^2 hybrid orbitals is closer to the energy of 2p orbitals than to that of the 2s orbital.

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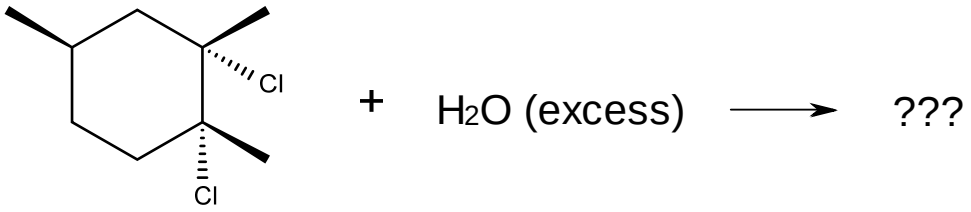
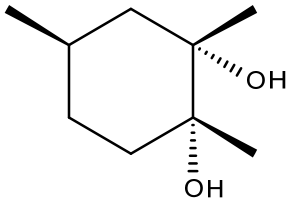
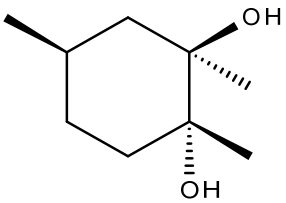
25. Which **structure(s)** would result from the reaction below?



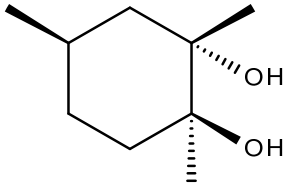
i)



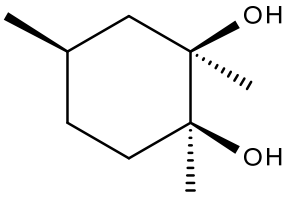
ii)



iii)



iv)



A) ii, iii
B) i, iv
C) iv only
D) i, ii, iii, iv
E) i only

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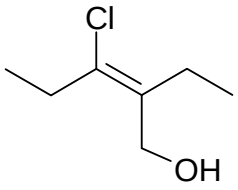
26. What is the **correct name** for the following molecule?



A) (*Z*)-3-chloro-4-methylhex-3-en-4-ol
B) (*E*)-3-chloro-2-ethyl-1-hydroxypent-2-ene
C) (*E*)-3-chloro-4-methylhex-3-en-4-ol
D) (*Z*)-3-chloro-2-ethylpent-2-enol
E) (*E*)-3-chloro-2-ethylpent-2-enol

27. Which of the following reactions would **NOT** be part of a radical polymerization of ethylene?

A) $RO\text{-}(CH_2CH_2)_nCH_2CH_2\bullet + RO\text{-}(CH_2CH_2)_mCH_2CH_2\bullet \rightarrow RO\text{-}(CH_2CH_2)_{n+m+2}\text{-}OR$
B) $RO\text{-}OR + \text{heat} \rightarrow 2\ RO\bullet$
C) $RO\text{-}CH_2CH_2\bullet + Cl_2 \rightarrow RO\text{-}CH_2CH_2Cl + Cl\bullet$
D) $RO\bullet + CH_2{=}CH_2 \rightarrow RO\text{-}CH_2CH_2\bullet$
E) $RO\text{-}(CH_2CH_2)_nCH_2CH_2\bullet + CH_2{=}CH_2 \rightarrow RO\text{-}(CH_2CH_2)_{n+1}CH_2CH_2\bullet$

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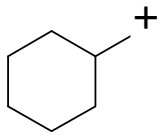
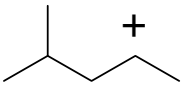
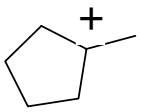
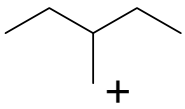
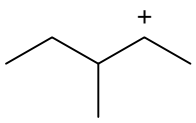
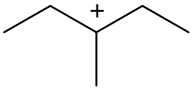
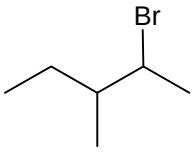
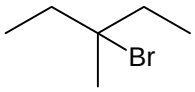
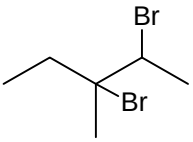
28. Rank the following carbocations in order of **increasing likelihood** to be found as **intermediates in an S_N1** reaction (from least likely to most likely):

(i) 
(ii) 
(iii) 
(iv) 

A) iv ≈ i < iii < ii
B) iv < ii < i < iii
C) ii < i ≈ iv < iii
D) iii < iv < ii < i
E) i ≈ iv < ii < iii

29. For the reaction between 3-methylpent-2-ene and HBr, **which of the following structures** correspond to the **intermediate(s) and product(s) formed**?

(i) 
(ii) 
(iii) 
(iv) 
(v) 

A) i, iii
B) all will be formed
C) i, ii, v
D) i, ii, iii, iv
E) ii, iv

Continued on next page…

30. Which of the following molecules has the **lowest molecular weight** and is **correctly named**?

    A) 2-isopropylprop-2-enoic acid
    B) 2-isopropylpropane
    C) 2-isopropylbuta-1,3-diene
    D) 2-isopropylprop-2-enal
    E) 2-isopropylcyclopentene

31. A 96 well plate assay is needed to screen a library of compounds for inhibitors of an enzyme that catalyzes the reaction A → G + H. Enzyme inhibition is measured by converting residual A into a coloured compound that can be quantified using a spectrophotometer. One well contains a solution of A only. What **type of well**/**result** is this?

    A) false negative result
    B) false positive result
    C) positive control well
    D) negative control well
    E) true positive result

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32. Indicate the **INCORRECT** statement regarding dopamine and homovanillyl alcohol (HVA), and their role in learning processes in bees:

    A) High-Throughput Screening involves using fast, parallel assays to test libraries of compounds for biological responses.
    B) Dopamine binds to HVA and suppresses its activity in bees.
    C) HVA selectively inhibits formation of unpleasant memories.
    D) HVA is an ingredient of Queen Mandibular Pheromone that helps the queen manipulate the learning of young bees.
    E) Dopamine is required for forming memories in both bees and humans.

33. Identify the **FALSE** statement regarding aromaticity:

    A) Part of the stability of DNA comes from the planarity of the aromatic rings in the base pairs.
    B) All bonds in an aromatic ring are the same length.
    C) All aromatic compounds can be represented by more than one resonance structure.
    D) Aromatic systems can contain heteroatoms such as O, N or S.
    E) An atom can donate 0, 1, or 2 electrons to an aromatic π-system but never 3 or 4.

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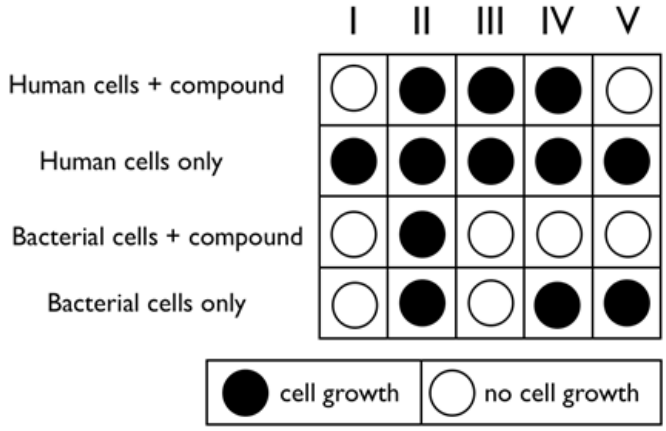
34. A combinatorial library was screened using microtiter plates for bactericidal antibiotics, compounds that selectively kill bacterial cells without harming human cells. Indicate which of the five compounds I - V studied is **most likely to be a bactericidal antibiotic**?



A) II
B) III
C) I
D) IV
E) V

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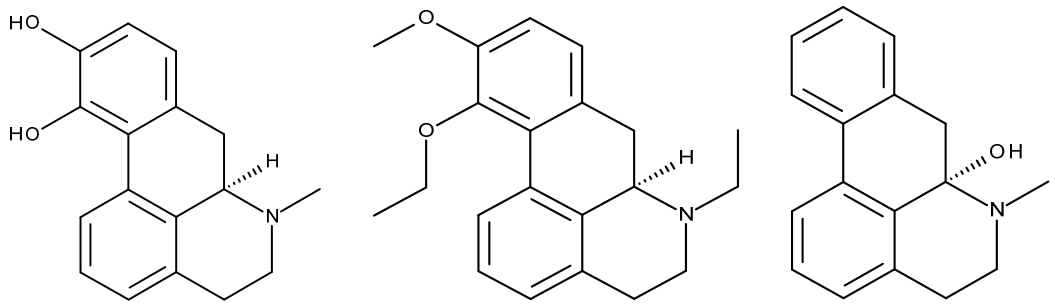
35. Three molecules from a combinatorial library are given below:



Finding a new drug typically requires at least 5000 failed compounds. Assuming that the substituents shown in the structures above can be used at any of the diversity sites, what is the **minimum number of ADDITIONAL substituents** you would need to use in order to give a good probability of finding a new drug?

A) 1
B) 10
C) 5
D) 7
E) 3

36. Indicate the **FALSE** statement regarding aromatic compounds:

A) Aromatic rings are less reactive than comparable linear systems.
B) Aromatic rings are planar.
C) Aromatic compounds must obey the Hückel 4n+2 rule.
D) Aromatic rings must consist of alternating single and double bonds.
E) Deprotonation of cyclopenta-1,3-diene at carbon-5 produces the aromatic $C_5H_5^-$ anion.

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Student Name: _____ Student No: _____

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Student Name: _____ Student No: _____

General data and equations. Other data appear with the questions.

There is a periodic table 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

K_w = 1.0×10^{-14}

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

1 mol = 10^3 mmol = 10^6 μmol

$v_0 = k[A]^m[B]^n$	$v = \lim_{t \to 0} \frac{1}{g}\frac{\Delta[G]}{\Delta t} = \frac{1}{g}\frac{d[G]}{dt}$
$[A]_t = [A]_0 \bullet e^{-kt}$	$ln\frac{[A]_t}{[A]_0} = -kt$
$[A]_t = [A]_0 - kt$	$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$
$v_0 = k[A]^2$ or $k[A][B]$	$\frac{d[E \bullet S]}{dt} = 0$
$v_0 = \frac{k_{cat}[E]_0[S]}{K_M + [S]}$	$k = Ae^{-E_a/RT}$

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Student Name: ________________________ Student No: __________________________

PERIODIC TABLE OF THE ELEMENTS

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]

End of Exam