Chemist: _____ Wednesday April 5, 2023

Knowledge:	/10
Thinking:	/8
Communication:	/8
Application	/10

Rates of Reactions

SCH4U1 UNIT 2 Test 1 (A of L)

Knowledge (10 marks)

Answer the following multiple choice questions by selecting the **BEST** answer for each question. Be sure to **record your selection in the table below** as only the Answer Grid will be evaluated.

1.	A	B	C	D	*3.*	A	B	C	D
2.	A	B	C	D	*4.*	A	B	C	D

1. $Ca_{(s)}$ was reacted with $HBr_{(aq)}$ to form $CaBr_{2(aq)}$ and the results were graphed (below)

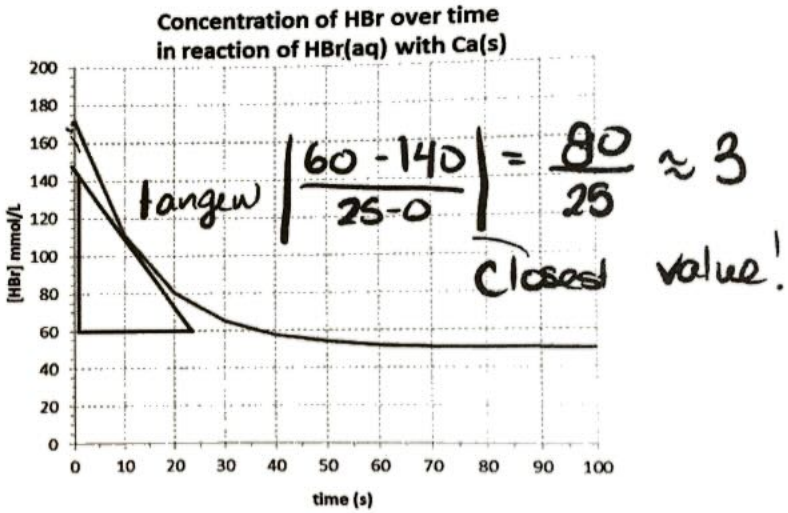
The **instantaneous rate** of reaction at 10s should be stated as as:

A. $\frac{\Delta[HBr]}{\Delta t}$ = -115 mmol/L•s

B. $-\frac{\Delta[HBr]}{\Delta t}$ = 3.00 mmol/L•s ✓ +ve consumption

C. $\frac{\Delta[HBr]}{\Delta t}$ = -3.00 mmol/L•s

D. $-\frac{\Delta[HBr]}{\Delta t}$ = 115 mmol/L•s



2. The rate of a reaction between two gases increases when the temperature is increased or when a catalyst is added. Which statements are **both incorrect** for the effect of these changes on the reaction?

	Increasing the temperature	Adding a catalyst
a)	Collision frequency increases	Activation energy does not change
b)	Proportion of effective collisions increases	Activation energy decreases
c)	Activation energy decreases	Collision frequency increases
d)	Collision frequency does not change	Activation energy decreases

SCH4U1
UNIT 2 – Test 1 (RATES)

Chemist: _____

Wednesday April 5, 2023 Haynes

3. The rate expression for a reaction is: **rate = $k[A]^2[B]$** . Which statements are **correct** for this reaction?

I. The reaction is second order with respect to A and first order with respect to B. ✓
II. The overall order of the reaction is 3. ✓
III. Doubling the concentration of only B would have a larger effect than doubling the concentration of only A ✗

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

4. Consider the following reaction.

$$2NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g) + NO_2(g)$$

At $T < 227$ °C the rate expression is rate = $k[NO_2]$. Which of the following mechanisms is consistent with this rate expression?

A. $NO_2 + NO_2 \rightleftharpoons N_2O_4$ *fast*
$N_2O_4 + 2CO \rightarrow 2NO + 2CO_2$ *slow*

C. $NO_2 + CO \rightarrow NO + CO_2$ *slow*

$r = [NO_2]^2$

B. $NO_2 + NO_2 \rightarrow NO_3 + NO$ *slow*
$NO_3 + CO \rightarrow NO_2 + CO_2$ *fast*

D. $NO_2 \rightarrow NO + O$ *slow*
$CO + O \rightarrow CO_2$ *fast*

5. a) In order to occur, the reactants in a chemical reaction must collide. Not all reactions, however, result in a chemical reaction occurring. State the **requirements that must be met** for the chemical reaction to occur.

✓ - enough energy for reaction to occur ($E_k > E_a$)
✓ - correct collision geometry

[2 marks]

b) Explain the effect of **increasing the concentration** of an aqueous reactant on the rate of a chemical reaction.

✓ - higher concentration means more particles in a given volume
✓ therefore higher collision frequency
✓ therefore rate increases 0.5 per check

[2 marks]

6. In the following chemical reaction

$$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$

0.475 mol of $Br_{2(aq)}$ are produced in 3.7500 minutes

Calculate the **average rate of the reaction**, in terms of **mol $Br^-_{(aq)}$ /s** [2 marks]

$\frac{0.475 \text{ mol } Br_2}{3.7500 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}} \times \frac{5Br^-}{3Br_2} = 3.52 \times 10^{-3}$ ✓ work ✓ answer

3sf

$-\frac{\Delta Br^-}{\Delta t} = 3.52 \times 10^{-3}$ mol Br^-/s ✓ ✓

- 0.5 com sf, notation

SCH4U1
UNIT 2 – Test 1 (RATES)

Chemist: Wednesday April 5, 2023 Haynes

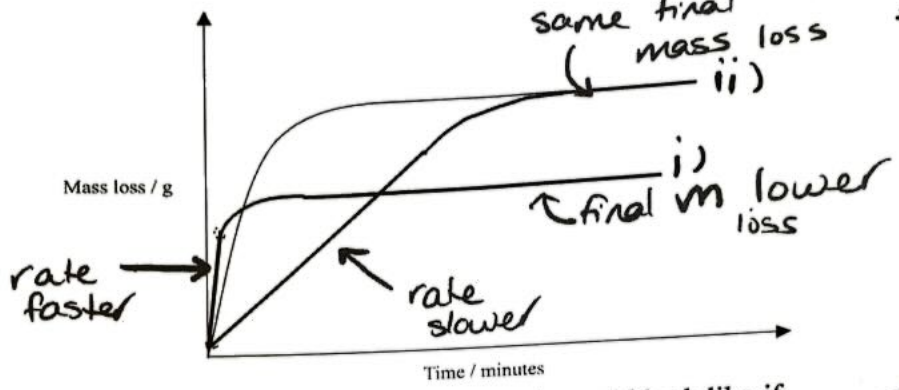
(8 marks)

Thinking

7. In experiment A below, **250.0 mL of 0.100 mol/L nitric acid is added to an excess of powdered of calcium carbonate at 30°C.** The rate of reaction is monitored by measuring the mass loss in the beaker.

$$2HNO_3(aq) + CaCO_3(s) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

$n = (0.250)(0.100)$
$= 0.025$ mol
limiting



a) **Draw lines** on the graph above, to **show what the graph would look like if:**

higher [ ]

i) Excess powdered calcium carbonate was reacted with 50.0 mL of 0.250 mol/L of nitric acid at 30°C. [1 mark]

$n = (0.250)(0.050)$ ← reference
$= 0.0125$ mol

ii) Excess powdered calcium carbonate was reacted with 250.0 mL of 0.100 mol/L nitric acid at 15°C. [1 mark]

same n rate same lower rate

b) ~~Use collision theory to explain why the initial rate of reaction is the fastest~~ [2 marks]

Describe the curve you would get for the conditions in i) if the calcium carbonate was limiting not HCl.

- rate would be faster (steeper)
- final mass loss would be the same.

8. At 480 °C nitrogen monoxide reacts with chlorine to form nitrosyl chloride (NOCl). All reactants and products are in the gaseous phase.

The kinetics of the reaction were studied at this temperature. The table shows the initial rate of reaction and concentrations of each reactant in a series of trials.

experiment	[NO(g)] (mol /L)	[Cl_2(g)] (mol /L)	Initial rate (mol/L • s)
1	0.0500	0.0200	3.4×10^{-1}
2	0.0250	0.0200	8.5×10^{-2}
3	0.0250	0.0800	3.4×10^{-1}

a) Determine **the order of the reaction with respect to NO and Cl_2.** (work must be shown for full marks)

NO - use 1 : 2

$\frac{3.4 \times 10^{-1}}{8.5 \times 10^{-2}} = \left(\frac{0.500}{.0250}\right)^n$

$4 = 2^n$

$n = 2$

Cl_2 use 2 + 3

$\frac{3.4 \times 10^{-1}}{8.5 \times 10^{-2}} = \left(\frac{0.080}{0.020}\right)^n$

$4 = 4^n$

$n = 1$

-0.5 com if no sentence order

for NO = 2 and Cl_2 = 1

(or explain in words)

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[2 marks]

Question 8 continued…..

b) Use experiment 2 to determine the **value of the rate constant (k)** for the reaction. Units are NOT required

$r = k[NO]^2[Cl_2]$ $k = 220$ (2sf)

$8.5\times10^{-2} = k(0.0250)^2(0.020)$ $k = 2.2\times10^2$ [1 mark]

c) Write the **rate law** for the reaction. $r = 2.2\times10^2[NO]^2[Cl_2]$ [1 mark]

Communication **(8 marks)**

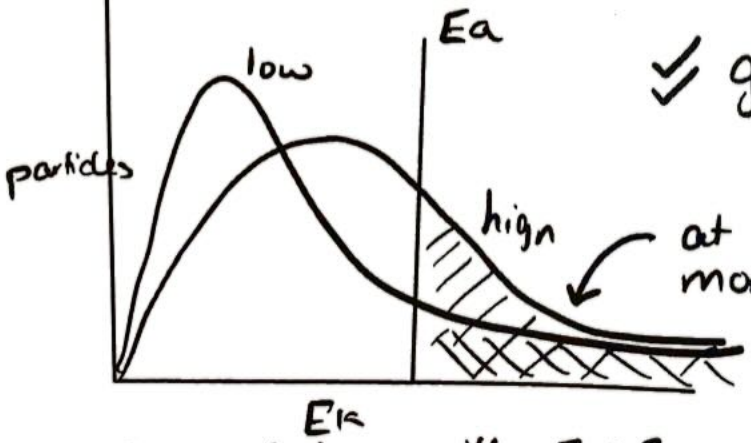
Overall form (showing work, units, significant figures etc.) throughout quiz _____[2 marks]

9. Explain the **difference** between an **average rate of reaction** and an **instantaneous rate of reaction.**
(Hint this question is NOT asking "how do you calculate …..") [2 marks]

an instantaneous rate is a change from reactants to products per unit time at a given point in time
an average rate is over an interval of time ✓
OWTTE

10. Draw a **Maxwell-Boltzmann Distribution** that **shows the main effect** of **temperature** on reaction rate, and **use/annotate/label** the diagram to **explain** the effect. [4 marks]

- 0.5 com if no axis labels or Ea label



✓ graph ✓ explanation (annotated or written)

at higher temperature more particles have Ek > EA (to right of EA line)

only particles with Ek>EA can collide with enough energy to react. More particles with EA > Ek will mean a higher proportion of effective collisions ∴ a higher reaction rate.

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Application **(10 marks)**

11. A student wishes to measure the rate of the following chemical reaction:

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + S(s) + SO_2(g)$$

Describe **one method** that could be used to measure the rate and **explain why** it would work: [2 marks]

various - $SO_2(g)$ produced so pressure, gas volume
mass loss in beaker
-HCl consumed so pH etc.

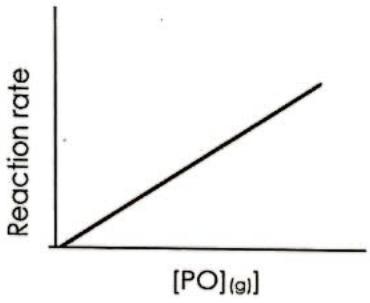
12. Nitrogen monoxide is reacted with hydrogen according to the following reaction:

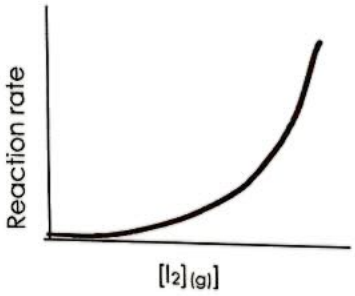
$$2PO_{(g)} + 2I_{2\,(g)} \rightarrow P_{2\,(g)} + 2OI_{2(g)}$$

A scientist carries out an experiment where they first change the concentration of PO only, and then change the concentration of I_2 only.

They determine that the **rate law for the reaction is $r = k[PO][I_2]^2$**

a) **Draw the graphs for the experimental results** that should be obtained from each experiment. [2 marks]





b) Describe how the graph for $I_2(g)$ would have changed if the rate law was $r = k[PO]$ [1 mark]

the graph would be a horizontal line excluding $[I_2] = 0$
(zero order for $I_2(g)$)

13. 11. A possible reaction mechanism has been proposed for a chemical reaction

(1) $[2PS(g) \rightarrow P_2S_2(g)] \times 2$
(2) $2P_2S_2(g) + S_2(g) \rightarrow 2P_2S_3(g)$

$4PS \rightarrow 2P_2S_2$

a) Determine the **overall chemical equation** that relates to this reaction mechanism. [1 mark]

$4PS_{(g)} + S_{2\,(g)} \rightarrow 2P_2S_3(g)$

Question continues on next page……

Chemist: _____
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Question 13 continued……

b) **State** which is the **rate-limiting (rate determining) step,** and **explain** your reasoning. [2 marks]

✓ step 2 - trimolecular collision

c) Use the mechanism to **determine the rate law** for the reaction. [2 marks]

$r = k\,[P_2S_2]^2[S_2]$

$[P_2S_2] \propto [PS]^2$

$r = k\,[PS]^2[S_2]$

allow ECF if step 1 identified

$r = k[PS]^2$

Extra space for rough work, continuation or corrections

SCH 4U1 Quiz: Atomic Theory and Bonding

ASSESSMENT OF LEARNING

Unit 1: Structure and Properties of Matter

Chemist:_____

Monday, February 27th, 2023

Knowledge: /10

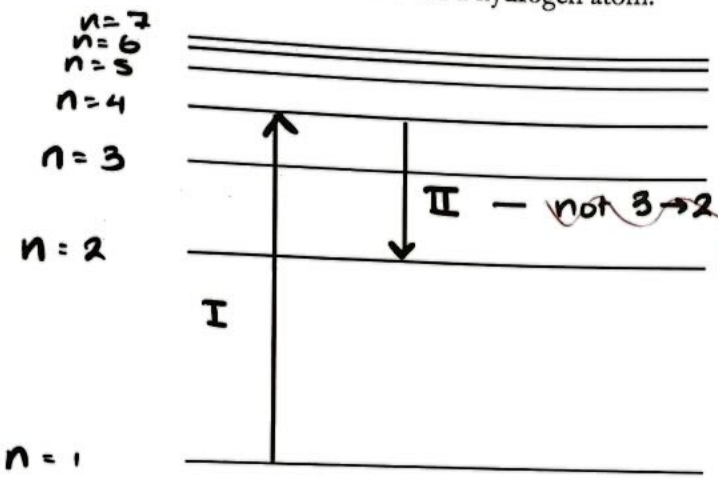
Thinking: /13

Communication: /13

INSTRUCTIONS:

- You **have 45 min regular time** (up to 75 min extra time) to complete the test
- You may use the data sheet and periodic table handout/file provided for all questions
- You may use a model kit if you wish.

1. This diagram shows energy levels 1 to 7 for a hydrogen atom.



II — not 3→2 since that is red (OK allowed since not stated red line)

a) On the diagram above, show:

I) An **excitation** to level 4 from the ground state for the hydrogen electron (1T)

II) An **emission** that would result in **orange light.** (1T)

b) Based on the diagram above, state and briefly explain **how many lines would be visible in the infrared region** of the emission spectrum of the hydrogen atom. (2T)

7→3, 6→3, 5→3, 4→3 would cause lines ✓ explanati
in infrared, ∴ 4 lines ✓
OWTTE (or words to that effect)

2. a) Write the **full electron configuration** for a selenium (Se) atom (1 C)

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$ ✓

Could be reversed

b) State **one atom** and **one ion of a different element** that would be isoelectronic with a selenium ion. (Se^{2-})

Atom: Kr ✓

Ion: As^{3-}, Br^-, Rb^+, Sr^{2+} ✓

must be the ion not just element. (2T)

Totals: /0 K /6 T /1 C

Chemist: _____ Monday, February 27th, 2023

SCH 4U1 Unit 1 Test 1 continued

3. An electron belonging to a **ground state atom** has the **first two quantum numbers n = 4 and ℓ = 1.**

a. State what information about the **location of this specific electron** is given by these two numbers (2 C)

4th main energy level ✓
p sublevel / a p orbital ✓

b. If this electron also has m_ℓ = -1 and is the **only electron in this orbital**, state the name of the element which has this electron as its final valence electron. (1 T)

$m_s = +\frac{1}{2}$
-1 — —

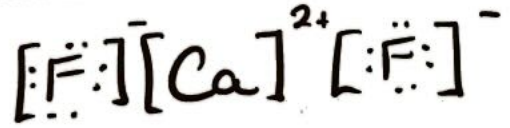
Ga (31st electron) ✓

c) **Precisely describe the location** of this electron (in words). *Include the rest of information that would be given by all 4 quantum numbers.* (not in a)

(4th main energy level, p sublevel)
✓first p orbital in the sublevel
✓first/clockwise e^- in the p orbital

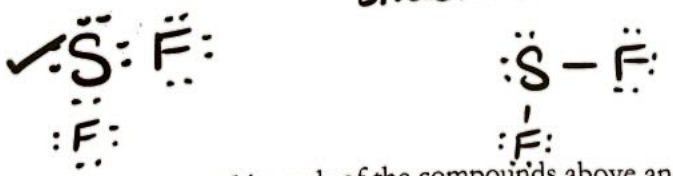
(2 C)

4. a) Draw the **Lewis Dot Diagram** for **calcium fluoride.** (1 C)



b) Draw the **Lewis Dot Diagram** for **sulfur difluoride.** (1 C)

structure OK too



c) **Identify the type of bond** in each of the compounds above and **explain the** difference between them.

calcium fluoride: ionic sulfur difluoride: (polar) covalent ✓ 1K total

in ionic + and - ions are attracted to each other (after transfer of e^-), in covalent ✓1K one (or more) pairs of e^- are shared ✓1T

(2K, 1T)

Totals: /2 K /2 T /6 C

Chemist: _____ Monday, February 27th, 2023

SCH 4U1 Unit 1 Test 1 continued

5. a) Draw the **3-dimensional (VSEPR)** for **nitrogen trichloride** and state its **AXE** formula.

Diagram (1 C)

AXE formula: AX_3E (1 K)

b) State the **shape of the electron distribution** for nitrogen trichloride: tetrahedral (1K)

c) Identify a **specific molecule** with the **same electron distribution** as nitrogen trichloride **but one less bonding domain** *(substitute a lone domain for a bonding domain)* and state the **molecular shape** of your molecule

Molecule formula or name: H_2O water (1T) other valid answers fine

State the **molecular shape** of the molecule you identified bent (1 K)

d) **State** the **bond angles** in nitrogen trichloride and the general molecule you drew. **Explain** the difference.

NCl_3 107° ✓K there are the same total ✓T
H_2O 104.5° domains, but more lone pairs in
H_2O. Lone pairs repel more than bond pairs
so angle is smaller ✓K (2K, 1T)

6. a) Draw a 3-dimensional diagram (**VSEPR**) diagram of ozone (**O_3**) and state its **bond angle(s).**

Diagram (1 C)

bond angle(s): 117° (1 K)

b) State the chemical formula for a molecule or ion that has the same molecular shape as O_3 **but a different AXE** formula.

H_2O (AX_2E_2) (1T)

c) **Explain why** the bond angle in the molecule or ion you identified in b) has a **different bond angle** from O_3. (2T)

there are 3 domains total in O_3 vs 4 in ✓
H_2O - each domain can be further apart ✓
so the angle is larger

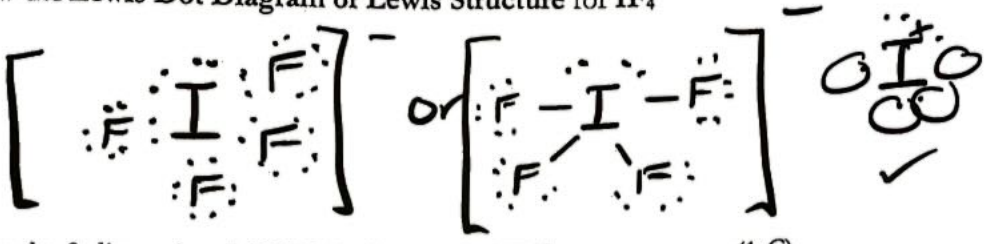
Totals: /2 K /2 T /6 C

Chemist: _____ Monday, February 27th, 2023

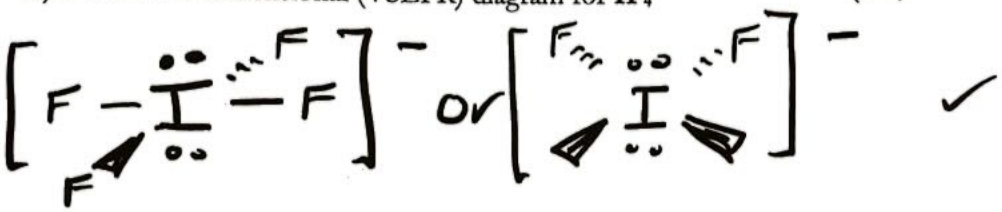
SCH 4U1 Unit 1 Test 1 continued

(1 C)

7. a) Draw the **Lewis Dot Diagram or Lewis Structure** for IF_4^-



b) Draw the 3-dimensional (VSEPR) diagram for IF_4^- (1 C)

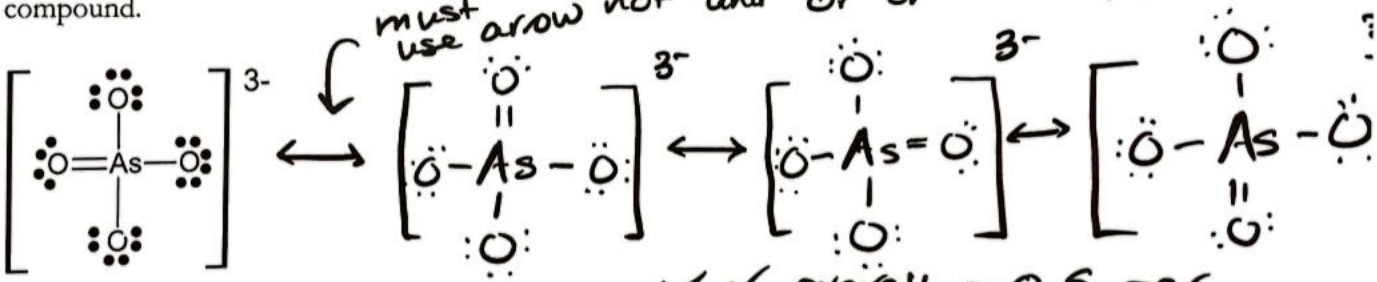


c) state the **molecular shape of IF_4^-** and it's **bond angle(s)**

molecular shape: square planar (1 K) bond angle(s): 90° (1 K)

8. The optimized **Lewis structure** for AsO_4^{3-} is shown below. Draw the **resonance structures** for this compound. (2C)

must use arrow not "and" or "or"



overall −0.5 per error

Space for rough work, continuations or corrections:

Totals: /2K /0T /4C

Chemist: _____

Friday March 10th, 2023

SCH4U1
UNIT 1 Test 2
Matter and Chemical Bonding

Knowledge:	/10
Thinking & Investigation :	/8
Communication:	/9
Application	/10

KNOWLEDGE & UNDERSTANDING (10 marks)

**** Answer the following multiple choice questions by selecting the BEST answer for each question. Be sure to record your selection in the table below as only the Answer Grid will be evaluated. ****

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

1. Which of the following types of electromagnetic radiation will have a **lower energy than red light**?

   a) infrared, X-rays, radio waves
   b) gamma rays, X-rays, ultraviolet
   c) radio waves, microwaves, infrared
   d) X-rays, microwaves, purple light
   e) infrared, ultraviolet, gamma rays,

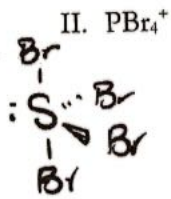
2. Which of the following sets of **quantum numbers are possible**?

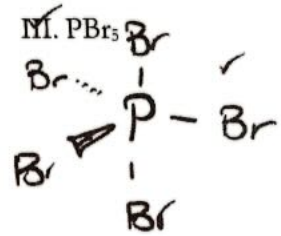
   a) $n=1, \ell = 1, m_\ell = 0, m_s = +\frac{1}{2}$
   b) $n=2, \ell = 1, m_\ell = 3, m_s = +\frac{1}{2}$
   c) $n=3, \ell = 0, m_\ell = 1, m_s = -\frac{1}{2}$
   d) $n=2, \ell = 2, m_\ell = +1, m_s = +\frac{1}{2}$
   e) $n=2, \ell = 1, m_\ell = 0, m_s = -\frac{1}{2}$

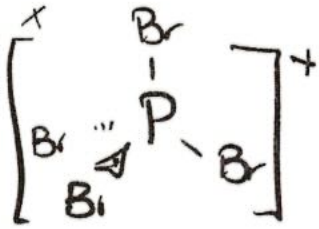
3. Identify which of the following contain a **bond angle of 90°**.

   I. SBr_4 II. PBr_4^+ III. PBr_5

   a) I and II only
   b) I and III only
   c) II and III only
   d) II only
   e) I, II and III







4. Which of the molecules: H_2O, PF_3, CHF_3, and BF_3, will be **polar**?

   a) H_2O and BF_3
   b) H_2O and CHF_3
   c) H_2O and PF_3
   d) H_2O, PF_3 and CHF_3
   e) H_2O, CHF_3 and BF_3

Chemist: _____

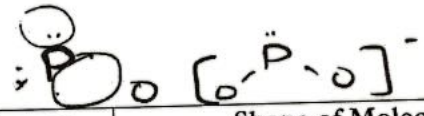
Friday March 10th, 2023

5. A polar molecule has a chemical formula XY_3. What **molecular shapes** could this molecule adopt?

I. Trigonal Pyramidal II. Trigonal Planar III. T-shaped

a) I only
b) I and III only
c) II and III only
d) I and II only
e) I, II and III

6. Which of the following is true for PO_2^-?



	Electron Geometry around central atom	Shape of Molecule
a)	Trigonal planar	Bent
b)	Trigonal planar	Trigonal planar
c)	Tetrahedral	Bent
d)	Trigonal bipyramidal	Trigonal planar
e)	Trigonal bipyramidal	T-shaped

7. In propanol (a type of alcohol), C_3H_7OH, there are covalent bonds, hydrogen bonds and London Dispersion Forces. Which bonds or forces are **broken** when propanol is **vaporized**?

a) hydrogen bonds and London forces
b) only hydrogen bonds
c) covalent bonds and hydrogen bonds
d) covalent bonds and London forces
e) covalent bonds, hydrogen bonds and London forces

Fill in the blanks: (1 mark per question)

8. There are a total of nine (9) orbitals within the third main energy level of an atom.

9. According to **VSEPR theory**, the **repulsion** between one o.s each electron domains is larger than between bonding electron domains

10. **Silicon (Si)** has a total of 6 **p orbitals** that are **completely or partially filled** with electrons.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ 1 1

3 full + 2 partially full

THINKING & INVESTIGATION **(8 marks)**

11. a) State the **abbreviated electronic configuration** of a **rhodium (Rh)** atom. (1 mark)

[Kr] $5s^2$ $4d^7$

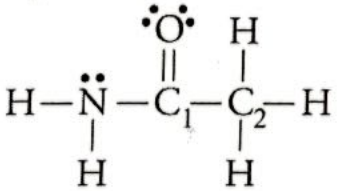
b) Using your answer in part (a), **state and explain all the possible ions** rhodium could theoretically form. (2 marks)

✓ Rh^{2+} by losing both 5s electrons ↿⇂ ↿ ↿ ↿

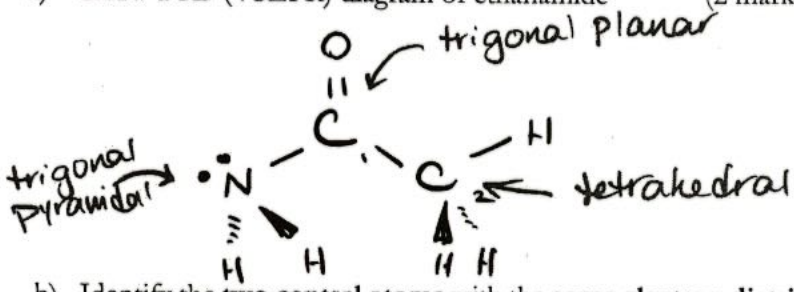
✓ Rh^{3+}, Rh^{4+}, Rh^{5+} since there are 3 unpaired d electrons (can lose some or all)

0.5 ions 0.5 explanation per mark

12. The Lewis Structure of ethanamide (CH_3CONH_2) is shown to the right:



a) Draw a 3D (VSEPR) diagram of ethanamide (2 marks)



b) Identify the **two central atoms** with the **same electron distribution** and state the **name of the molecular shapes** around each of these central atoms. (2 marks)

N - trigonal pyramidal and C_2 tetrahedral

c) C_1 and N have the **same number of bonding domains** but **different molecular shapes**. Explain why. (1 mark)

N also has a lone pair, so 4 total domains that influence the shape, but C_1 only has 3 domains total

OWTTE

SPACE FOR ROUGH WORK (will not be marked)

COMMUNICATION **(9 marks)**

13. Bohr's model of the atom was developed using the emission spectrum of the hydrogen atom, however earlier models of the atom made Bohr's model possible. Two of these models were the Rutherford model and the Thompson model. **Explain the change (advance) that one of these models made over the other.** State the name of the experiment that was used to make this change *(which model was the starting point, and what did the later model add to understanding of the atomic model. Description of the specific experiment is not necessary)* (3 marks)

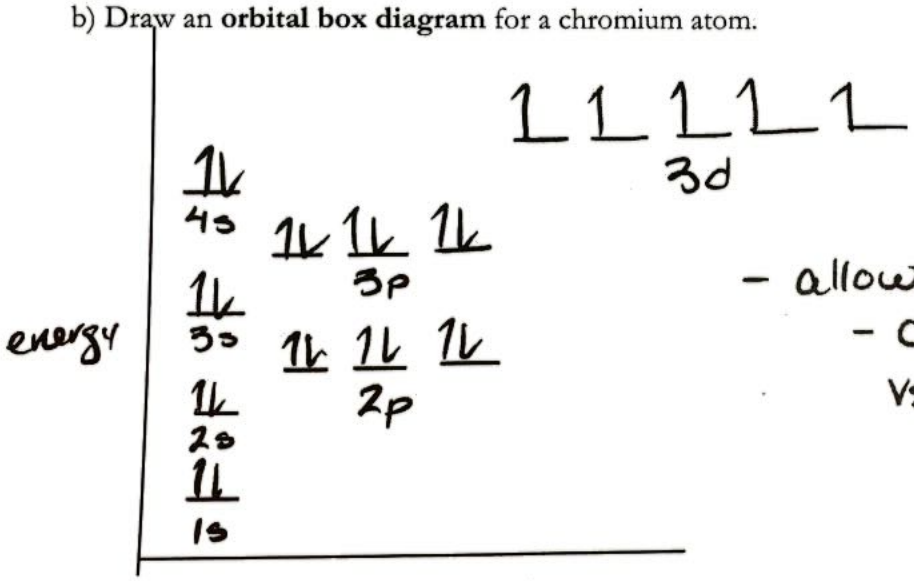
Rutherford's model with the gold foil experiment advanced atomic theory over the thompson model. Rutherfords experiment added the idea of the positively charged nucleus, with most of the atom being empty space

14. a) State and explain the **difference between** the predicted and actual electron configuration for a chromium (Cr) atom (2 marks)

predicted [Ar]$4s^2$ $3d^4$ actual [Ar]$4s^1$ $3d^5$

there is a potential energy minimum /stability boost from a full or half full sublevel, so an s electron is "bumped" from 4s to give half-full 3d OWTTE

b) Draw an **orbital box diagram** for a chromium atom. (2 marks)



- allow ECF from a
- 0.5 for predicted vs. actual

15. Using your knowledge of atomic theory, state one **similarity** and one **difference** between **s and p orbitals.** (2 marks)

Similarity - all orbitals contain $2e^-$ max

difference - s one per level, p 3 per level

- start n=2 for p, start n=1 for s

allow other valid answers

APPLICATION **(10 marks)**

16. Briefly describe **one application of spectroscopy.** (1 mark)

various - use of spectra detected to determine star composition, metal composition in recycling or ore testing, medical imaging etc.

17. You have been supplied with **three unidentified solids** and you carry out a series of tests in the lab. You get the following results:

Substance	Solubility in H_2O	Electrical Conductivity of solid
W	Yes	No
X NPM or M	No	No ← not metal
Y	No	Yes ← metal

a) **Identify** which one of these solids are most likely to be a **nonpolar molecular** compound and a **metallic** compound. (2 marks)

NPM: X M: Y

b) The remaining aggregate is either salt (NaCl) or sugar ($C_{11}H_{22}O_{11}$). Identify **one further test or piece of information** that could be used to distinguish between the two types of aggregate. (1 mark)

aqueous electrical conductivity or melting point

c) Using your knowledge about **properties of aggregates, intermolecular forces and bonding, explain why** the test you chose distinguishes between salt and sugar *(what would happen, and why?)*. (3 marks)

(aq) conductivity - when ionic compounds such as NaCl dissolve they dissociate and ions can move to carry charge. when polar molecular compounds like sugar dissolve there are no delocalized e^- or separated ions so they do not conduct

✓ ionic vs pm.
✓ why ionic conducts
✓ why PM does not

melting point - NaCl is ionic and sugar is polar molecular. Ionic bonds are stronger than dipole-dipole attractions (and hydrogen bonds) in sugar. Therefore the melting point of an ionic compound is higher than polar molecular

✓ ionic vs PM ✓ forces
✓ which stronger

SCH 4U1 –Haynes

Chemist: _____

Friday March 10th, 2023

18. **Insulators** are used as coating in electrical equipment to separate electrical conductors since they ~~do~~ not **allow** current to pass through the coating. **Porcelain** is a commonly used insulator coating for electrical equipment that is **exposed to environmental conditions such as rain and snow.** do not conduct

don't dissolve in water

One major advantage of this coating is that it is **extremely strong and durable** (lasts a long time) if properly cared for. However, a disadvantage is that **the coating can be cracked or damaged by impacts (blows).** hard brittle

a) Based on this information, **which type of aggregate** is porcelain made of? (1 mark)

network solid

b) Referring to your choice from part a., explain the **type(s) of bonding and properties that exist** in the aggregate that would explain the properties of the porcelain insulation coating described above. (2 marks)

- a network solid does not dissolve in water (rain/snow) because it is held together by covalent bonds, and the LDF interacting with water molecules will not break covalent bonds
- they do not conduct electricity when solid because there are no ions or electrons to carry charge
- they are hard but brittle because covalent bonds are strong, but if broken cannot be re-formed

EXTRA SPACE ✓✓ any 2. correct.

If you do not have enough space to answer a question or make a mistake and need to cross out your answer, ***continue/redo questions here. Be sure to clearly show which question you are continuing or redoing!***

Chemist: _____

Thursday, April 14, 2022

Energy Changes in Reactions

SCH4U1 UNIT 2 Quiz 2 (A of L)

Knowledge:	/10
Thinking:	/8
Communication:	/10
Application	/10

KNOWLEDGE (10 marks)

Answer the following multiple choice questions by selecting the **BEST** answer for each question. Be sure to **record your selection in the table below** as only the Answer Grid will be evaluated.

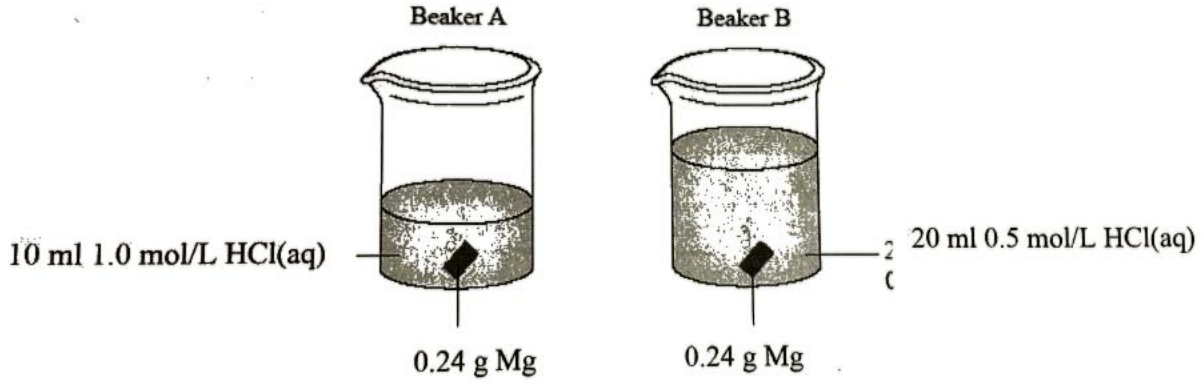
MULTIPLE CHOICE ANSWER GRID

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

1. An **endothermic reaction** is one in which:

   A. heat is transferred from the system into the surroundings.
   B. there is no transfer of heat.
   C. heat is transferred from the surroundings into the system
   D. potential energy is transformed into kinetic energy
   E. two of the above are correct

2. **Identical pieces of magnesium** are added to two beakers, A and B, containing **hydrochloric acid.** Both acids have the **same initial temperature** but their **volumes and concentrations differ.**



   Assuming the **reaction of Mg with HCl is exothermic**, which statement is correct?

   A. The maximum temperature in A will be higher than in B.
   B. The maximum temperature in A and B will be equal.
   C. The maximum temperature in B will be higher than in A.
   D. The mass of Mg will decrease more slowly in A than in B
   E. Both A and D are correct.

3. For which one of the following substances is the standard enthalpy of formation, ΔH^{o}_{f}, **NOT** equal to zero?

   A. $Hg_{(l)}$
   B. $O_{2(l)}$
   C. $Cl_{2(g)}$
   D. $Fe_{(s)}$
   E. $Ca_{(s)}$

4. The following equation shows the simple decomposition of magnesium oxide.

$$2MgO(s) \rightarrow 2Mg(s) + O_2(g) \quad \Delta H^\circ = +604kJ$$

Which statement is **correct** for this reaction?

A. Equal energy is released for every mol of oxygen gas and magnesium formed. ✗
B. 302 kJ of energy are released for every mol of magnesium oxide reacted. ✗
C. 604 kJ of energy are absorbed for every mol of magnesium formed .
D. 302 kJ of energy are absorbed for every mol of magnesium formed. ✓
E. 604 kJ are released for every mol of oxygen gas formed. ✗

5. Determine the **enthalpy change** when 1.3kg of $H_2O_{(l)}$ at 0°C is converted to $H_2O_{(s)}$ at 0°C. The enthalpy of fusion of H_2O is 332 J/g.

l→s -ve 1300×332 -ve)

A. -392J
B. -432kJ
C. -432J
D. +392J
E. + 432kJ

KNOWLEDGE CONTINUED

6. The enthalpy change for a chemical reaction can be calculated in various ways. One way is to bond enthalpies and another is to use standard enthalpies of formation. State **whether the bond enthalpy method will give a more or less accurate value than standard enthalpies of formation** for ΔH for the reaction and give **two reasons** for your choice. [3 marks]

bond enthalpies are less accurate
- values are averages from same bond in different molecular environments
- state changes are not considered since all bond enthalpy values are from gaseous compounds

7. The following statements are **false**. **Write a corrected statement** below each one (*yes, there may be more than one way to make each statement correct, and more than one correction to make in the statement!*). [2 marks]

a) Bond enthalpy is the energy required to break a compound into atoms in their standard state.

(1 mole of) a specific bond when the compound is in a gaseous state

b) Object A and B are heated from 30°C to 70°C. If both objects are the same volume, but A has a lower specific heat capacity than B, more energy will be required to raise the temperature of A than B.

both objects are the same mass

less energy will be required

THINKING (8 marks)

9. Use the equations provided to **find the enthalpy change** associated with the reaction below.

$$SO_2(g) + SF_4(g) \rightarrow 2\ OF_2(g) + 2\ S(s)$$

OF2 1) $OF_2(g) + H_2O(l) \rightarrow O_2(g) + 2\ HF(g)$ $\Delta H° = -276.66$ kJ
SF4 2) $4\ HF(g) + SO_2(g) \rightarrow SF_4(g) + 2\ H_2O(l)$ $\Delta H = +827.5$ kJ
S 3) $SO_2(g) \rightarrow S(s) + O_2(g)$ $\Delta H° = +296.90$ kJ

$-2\times$(1) $2O_2(g) + 4HF(g) \rightarrow 2OF_2(g) + 2H_2O(l)$ $\Delta H = -2(-276.66\ kJ)$
$-1\times$(2) $SF_4(g) + 2H_2O(l) \rightarrow 4HF(g) + SO_2(g)$ $\Delta H = -(827.5\ kJ)$ ✓
$2\times$(3) $2SO_2(g) \rightarrow 2S(s) + 2O_2(g)$ $\Delta H = 2(+296.90)$

$2\cancel{O_2}(g) + 4\cancel{HF}(g) + SF_4(g) \rightarrow 2OF_2(g) + 2\cancel{H_2O}(l) + 4\cancel{HF}(g) + \cancel{SO_2}(g) + 2S(s) + 2\cancel{O_2}(g)$
$+ 2\cancel{H_2O}(l) + \cancel{2}\,1\,SO_2(g)$
$SO_2(g) + SF_4(g) \rightarrow 2OF_2(g) + 2S(s)$ ✓
0.5 target verify

$\Delta H = +319.62$
1 dec pl sf
−0.5 com

com deductions if work not clear

$\Delta H = +319.6$ kJ
0.5 answer

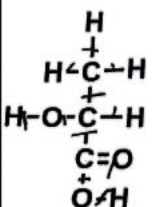
[4 marks]

10. The equation for complete combustion of lactic acid is as follows:

$$C_3H_6O_{3(s)} + 3O_{2(g)} \rightarrow 3CO_{2(g)} + 3H_2O_{(g)}$$

List and organize the appropriate bonds and **their associated energy values** that would be used to calculate the ΔH for this reaction *(in other words, show the work you would do to calculate ΔH).*

Calculation of ΔH using the enthalpies **is NOT required.**



ctic acid

Broken		Formed	
2 C–C	2(347 kJ)	3×2 C=O	6(746 kJ)
4 C–H	4(413 kJ)	3×2 O–H	6(464 kJ)
2 C–O	2(358 kJ)		
2 O–H	2(464 kJ)		
1 C=O	1(746 kJ)		
3 O=O	3(498 kJ)		

−0.5 per error

com for organization (clarity)

[4 marks]

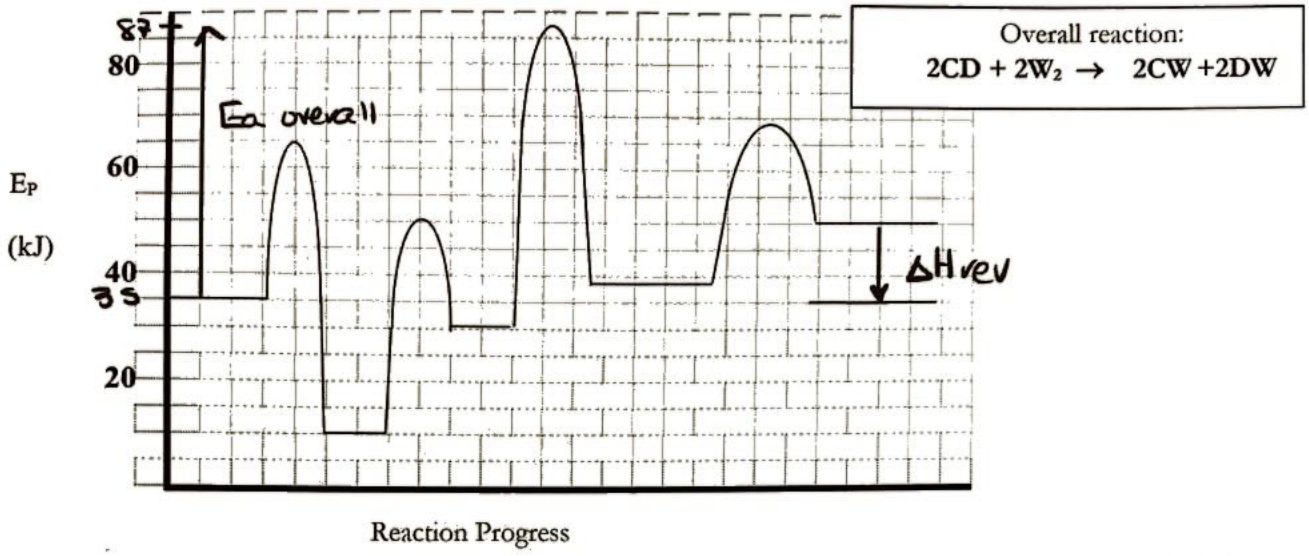
Chemist: _____

Friday April 14th, 2023

COMMUNICATION (10 marks)

Overall form (units, significant figures, showing work etc.) throughout test _____ [2 marks]

10. An energy level diagram (reaction profile) for a chemical reaction is shown below:



a) If you were proposing a reaction mechanism for this reaction, **how many steps** would you need to include in your mechanism? [1 mark]

4 steps ✓

b) If you were given no other information, **suggest, with a reason** which step suggest is the **rate-limiting step** [2 marks]

step 3 ✓ - highest activation energy

c) Use your graph to **determine the following values:** [2 marks] not 85

i) The **overall activation energy** for the forward reaction 87 - 35 = 52 kJ ✓

ii) The **overall enthalpy change** for the reverse reaction -15 kJ ✓

accept reasonable graph reading

11. "Dry ice" (solid carbon dioxide) is used to create mist or fog on movie or theatre sets because it sublimes. The enthalpy of **sublimation of carbon dioxide** is + 32.3 kJ/mol CO_2 (s).

a) Write the **thermochemical equation** for this process. [1 mark]

$CO_{2(s)} + 32.3\,kJ \longrightarrow CO_{2(g)}$

b) **State, with a reason**, whether the **final temperature of the surroundings of the dry ice will be higher or lower** than the initial temperature when this process takes place. [2 marks]

✓ final temperature will be lower
✓ energy from surroundings was used to change CO_2 state / went into system

Chemist: _____

Friday April 14th, 2023

APPLICATION

(10 marks)

12. Sodium sulfite and bleach (NaClO) react according to the following equation:

$$NaClO_{(aq)} + Na_2SO_{3(aq)} \rightarrow NaCl_{(aq)} + Na_2SO_{4(aq)}$$

A calorimetry experiment was carried out to determine the **molar enthalpy of reaction of sodium sulfite.** 35.5 g of sodium sulfite ($Na_2SO_{3(aq)}$) was added to a calorimeter containing 75.00 mL of bleach solution, with the bleach as the excess reactant. The results of the experiment are shown below:

a) Calculate the **molar enthalpy of reaction of sodium sulfite.**

$q = mc\Delta T$ water

$m = 75.00 mL \times 1 g/mL = 75.00 g$

$c = 4.18 J/g \cdot °C$

$T_i = 21°C$

$T_f = 50°C$

$q = (75.00)(4.18)(50-21)$

$q = 9091.5 J$

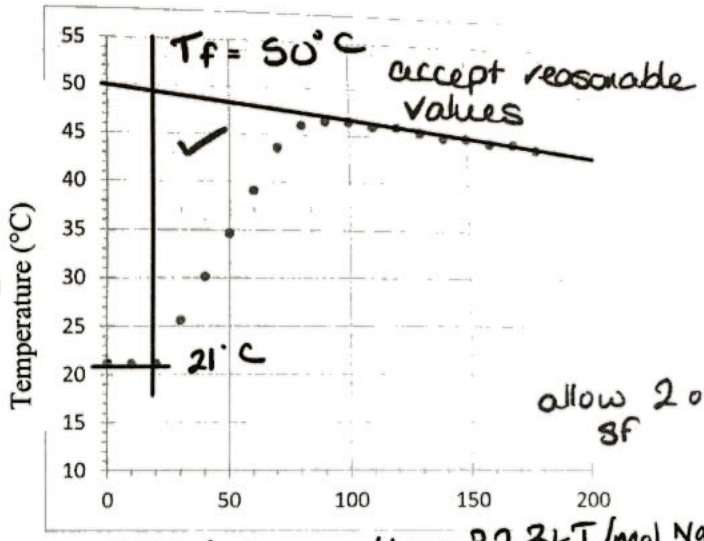
$\therefore \Delta H = -9091.5 J$

$\Delta H = -q$

$35.5 g\ Na_2SO_3 \times \frac{1 mol}{126.04 g} = 0.2816 mol$

$\Delta H = \frac{-9091.5 J}{0.2816 mol} = 32285 J/mol$ or $32.3 kJ/mol$

$\Delta H = -32.3 kJ/mol\ Na_2SO_3$



[4 marks]

b) State **which assumption of calorimetry is NOT true in this experiment**, and how you know. [1 mark]

no energy is transferred from/to the environment outside the calorimeter - since the final temp is falling after rxn. is complete, energy must be lost.

13. The equation for combustion of glucose is shown below:

$$C_6H_{12}O_6\ (l) + 6\ O_2\ (g) \rightarrow 6\ CO_2\ (g) + 6\ H_2O\ (l) \quad \Delta H° = -2808\ kJ/\ mol\ C_6H_{12}O_6$$

Using the enthalpies of formation ($\Delta H_f°$) values provided on your data sheet, determine the **standard molar enthalpy of formation** ($\Delta H_f°$) for **glucose,** $C_6H_{12}O_6$ (l).

[3 marks]

liquid not gas

$\Delta H = [6\Delta H_f CO_{2(g)} + 6\ \Delta H_f H_2O_{(l)}] - [\Delta H_f C_6H_{12}O_6 + 6\Delta H_f O_{2(g)}]$

$-2808 kJ = [6(-393.52 kJ) + 6(-285.83 kJ)] - [\Delta H_f C_6H_{12}O_6 + 6(0)]$

dec places addition

$-2808 kJ = -4076.1 kJ - \Delta H_f C_6H_{12}O_6$

$\Delta H_f C_6H_{12}O_6 = -1268.1 kJ$

$\Delta H_f° = -1268 kJ/mol\ C_6H_{12}O_6$

conv. units

14. When ice from the freezer at -15°C is put in a soft drink that is at room temperature, the ice does not start to melt immediately, but the temperature of the drink does start to decrease immediately. **Explain why, and when the ice will start to melt**, using **energy and energy transfer**.

[2 marks]

- as soon as the ice is put in the drink energy transfers from the drink (so temp ↓) until the ice reaches 0°C

- when the ice reaches 0°C it will start to melt (energy from drink will break Hydrogen Bonds in ice)

Space for rough work, continuations or corrections

Chemist:_____

May 2, 2023

SCH 4U1 UNIT 3 Test 1
Chemical Systems and Equilibrium

Knowledge & Understanding:	/10
Thinking and Investigation	/10
Communication:	/8
Application:	/10

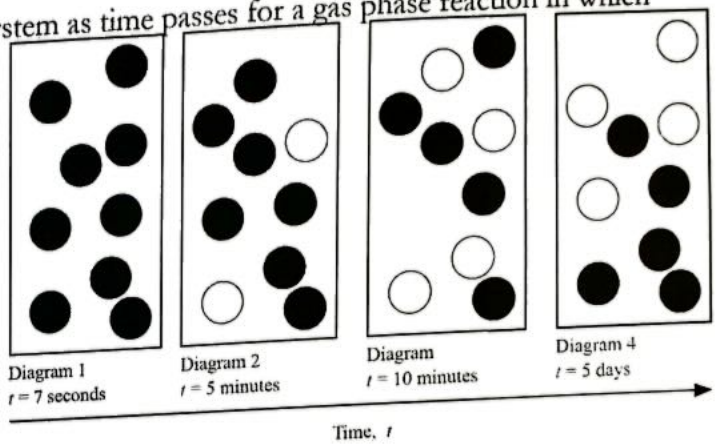
[10 marks]

KNOWLEDGE & UNDERSTANDING

Part A - Multiple Choice. Select the letter of the choice that ***best*** completes the statement or answers the question.

1.	A	B	C	D	*4.*	A	B	C	D
2.	A	B	C	D	*5.*	A	B	C	D
3.	A	B	C	D	*6.*	A	B	C	D

1. The sequence of diagrams represents the system as time passes for a gas phase reaction in which reactant **X** is converted to product **Y**.



Which statement is correct?

A. At $t = 5$ days the rate of the forward reaction is greater than the rate of the reverse reaction. ✗

B. At $t = 7$ seconds the reaction has reached completion. ✗

C. At $t = 10$ minutes the system has reached a state of equilibrium. → no change 10min - 5days

D. At $t = 5$ days the rate of the forward reaction is less than the rate of the reverse reaction. ✗

2. Which of the following is an example of a heterogeneous equilibrium?

A. $2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)}$ ✗

B. $Cu^{2+}_{(aq)} + 2OH^-_{(aq)} \rightleftharpoons Cu(OH)_{2(s)}$

✗ C. $Fe^{3+}_{(aq)} + SCN^-_{(aq)} \rightleftharpoons FeSCN^{2+}_{(aq)}$

D. None of the above

3. If the equilibrium constant for a given reaction is 0.400, what is the equilibrium constant for the **reverse reaction**?

A. 2.50

B. -0.400

C. - 2.50

D. 0.400

4. What will happen to the position of equilibrium and the value of the equilibrium constant when the **temperature is increased** in the following reaction?

K↑ energy

$$Br_{2\,(g)} + Cl_{2\,(g)} \rightleftharpoons 2BrCl_{(g)} \quad \Delta H = +14\text{ kJ}$$

	Position of equilibrium	Value of equilibrium constant
A.	Shifts towards the left	Decreases
B.	Shifts towards the left	Increases
C.	Shifts towards the right	Decreases
D.	Shifts towards the right	Increases

5. The carbon dioxide in a closed bottle of carbonated soda pop will display what type of equilibrium?

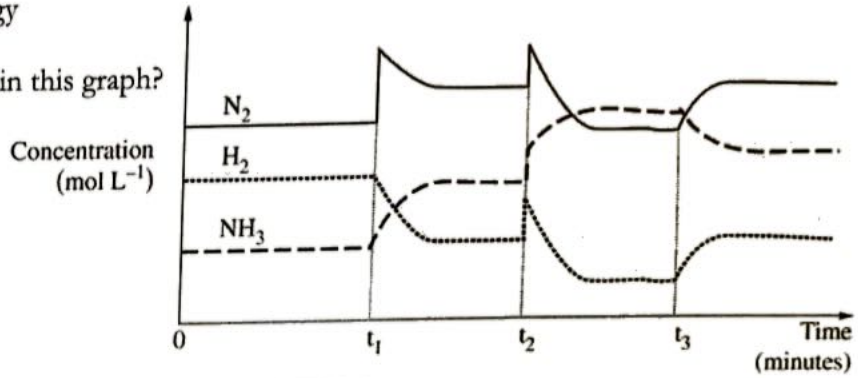
$$CO_{2\,(g)} \rightleftharpoons CO_{2\,(aq)}$$

A. Phase equilibrium
B. Static equilibrium
C. Chemical equilibrium
D. Solubility equilibrium

6. The following graph shows three different stresses on the reaction

$N_{2(g)} + 3H_{2(g)} \leftrightarrows 2NH_{3(g)}$ + energy

Which stresses occur, in order, in this graph?



A. Container volume decreases, temperature increases, [NH_3] decreases
B. [N_2] increases, container volume decreases, temperature increases
C. [N_2] decreases, container volume increases, temperature increases
D. [N_2] increases, container volume decreases, temperature decreases

7. Identify the following statements as **True (T) or False (F)** (0.5 each, 2 marks total)

a) A system must be isolated for a system to reach equilibrium. F

b) In the chemical reaction below, an increase in container volume will result in a system shifting towards the left. F

$2A_{(s)} + 2B_{(g)} \rightleftharpoons + 3C_{(g)}$ more gas moles

c) An increase in temperature will shift the equilibrium position in favour of the endothermic reaction. T

d) A glass of water with ice at 0°C is an example of phase equilibrium. T

8. The full name of equilibrium is "dynamic equilibrium". Explain **how a saturated solution of sodium chloride** in water shows the properties ~~of a dynamic equilibrium~~ both dynamic and equilibrium [2 marks]

at equilibrium - no macroscopic changes (quantity of solid same etc.)
dynamic - both forward + reverse reactions (dissolving + crystallizing) continue to occur.

THINKING & INVESTIGATION [~~8~~ marks] 10

9. Consider the following equilibrium:

$$2NOCl_{(g)} \rightleftharpoons 2NO_{(g)} + Cl_{2(g)}$$

When 2.00 moles of $2NO_{(g)}$ and 1.50 mol of $Cl_{2(g)}$ are placed in a 1.00 L flask at 445 K, the **percentage reaction** for the reverse reaction is 65.0%

Determine the **equilibrium concentrations** of NOCl and Cl_2 [~~5~~ 4 marks]

$2NOCl_{(g)} \rightleftharpoons 2NO_{(g)} + Cl_{2(g)}$

I	0	2.00 mol/L	1.50 mol/L
C	+2 ☺	−2 ☺	− ☺
E	+2 ☺	2.00 − 2☺	1.50 − ☺

shift left (no NOCl)

NO is the limiting reactant (by inspection)

max NOCl is 2 mol/L since 1:1 (can do math) here ~~but~~ formal proof not needed

0.65 × 2.00 = 1.300

2☺ = 1.300

☺ = 0.650

[NOCl] = 1.30 mol/L

$[Cl_2]$ = 1.50 − 0.650 = 0.850 mol/L

10. The following equation represents the equilibrium reaction for the synthesis of phosgene gas, $COCl_{(g)}$: At 473 K, the value of **Kc** for this reaction is 125

$$2CO_{(g)} + Cl_{2(g)} \rightleftharpoons 2COCl_{(g)}$$

The initial concentrations in the container are:
$[COCl_{(g)}]$ = 0.85 mol/L $[CO_{(g)}]$ = 0.20 mol/L $[Cl_{2(g)}]$ = 0.20 mol/L

(a) Determine **which way the system must shift** to reach equilibrium. Show your work. [2 marks]

$K = \frac{[COCl]^2}{[CO_{(g)}]^2[Cl_2]}$

$Q = \frac{(0.85)^2}{(0.20)^2(0.20)^2}$

$Q = 90.3$

$Q > K_{eq}$ ∴ must shift to right to reach equilibrium.

11. 2.50 mol of $SO_{2(g)}$ and 2.50 mol of $PO_{2(g)}$ are placed in a 2.00L container and allowed to reach equilibrium. **Using an ICE table,** determine the **concentration of $SO_{3(g)}$** and $SO_{2(g)}$ at equilibrium.

$$SO_{2(g)} + PO_{2(g)} \rightleftharpoons PO_{(g)} + SO_{3(g)} \qquad K_{eq} = 4.85 \times 10^2$$

$SO_{2(g)} + PO_{2(g)} \rightleftharpoons PO_{(g)} + SO_{3(g)}$

	$SO_{2(g)}$	$PO_{2(g)}$	$PO_{(g)}$	$SO_{3(g)}$
I	$\frac{2.50 mol}{2.00 L} = 1.25 mol/L$	$\frac{2.50 mol}{2.00 L} = 1.25 mol/L$	0 ✓	0
C	$-y$	$-y$	$+y$	$+y$
E	$1.25-y$	$1.25-y$	$+y$	$+y$

$K_{eq} = \frac{[PO_{(g)}][SO_{3(g)}]}{[SO_{2(g)}][PO_{2(g)}]}$

$4.85 \times 10^2 = \frac{(y)^2}{(1.25-y)^2}$ ✓

perfect square

$\sqrt{4.85 \times 10^2} = \frac{y}{1.25-y}$ ✓

$22.027 = \frac{y}{1.25-y}$

$y = 0.124$

$[SO_3] = 0.124$ mol/L ✓
$[SO_2] = 1.13$ mol/L

[4 marks]

COMMUNICATION **[8 marks]**

Overall form (units, significant figures, showing work etc.) throughout test _____[2 marks]

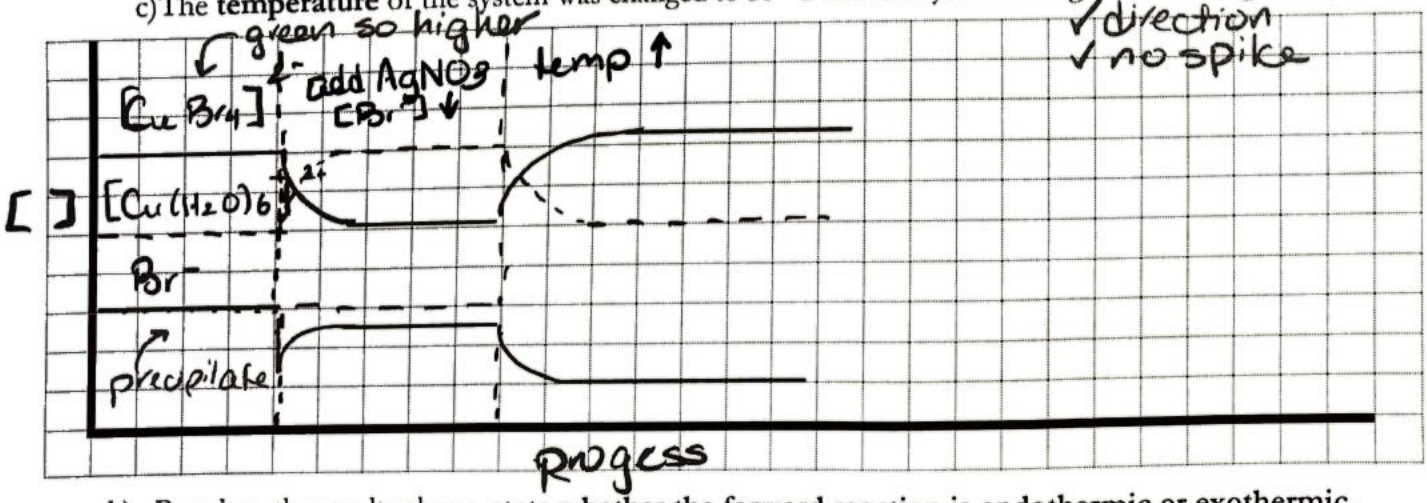
12. Sketch the following experiment using the equilibrium below:

$$[Cu(H_2O)_6]^{2+}_{(aq)} + 4\,Br^-_{(aq)} \rightleftharpoons [CuBr_4]^{2-}_{(aq)} + 6H_2O\,(l)$$
(blue) **(green)**

a) At the start of an equilibrium experiment carried out at 25°C, the **system was at a state of equilibrium** and the mixture was green. (1 mark)
✓ horizontal
$CuBr_4$ highest, no H_2O

b) **$AgNO_{3(aq)}$ was added**. A cream-coloured precipitate was observed, and the solution changed colour to blue *(solubility rules are found on your green sheet!)*. (2 marks)
✓ removal
✓ shift

c) The **temperature** of the system was changed to 35 °C and the system changed colour to green. (2 marks)
✓ direction
✓ no spike



b) Based on the results above, state whether the forward reaction is endothermic or exothermic. (1 mark)

↑ temp shifts right, ∴ endothermic ✓

APPLICATION

[~~12~~ 10 marks]

13. One of the common acid-rain causing pollutants from factories is $NO_{2(g)}$. This red/brown gas is responsible for smog above factories and cities. NO_2 is one of the contributors to acid rain, since the $NO_{2(g)}$ reacts with water in the air to form nitric acid

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$$
(brown) (colourless)

The K_{eq} **for this reaction is 2.0 x 10^2 at 25°C and the forward reaction is exothermic.**

(a) At 25°C air near cities and factories is usually fairly **colourless**, even if $NO_{2(g)}$ is being produced. **Explain why.**

Keq is quite large, so the equilibrium position will have more N2O4 than NO2 (N2O4 colourless)

[1 mark]

(b) Explain **why acid rain is more likely to occur in warm weather than in cold weather.**

the reverse reaction is favoured by higher temp. ✓
∴ more NO2 at higher temp (warmer weather) ✓
(NO2 reacts to form acid rain) ∴ more acid rain

[2 marks]

14. The Haber Process has been an extremely important industrial reaction since it's development by F. Haber prior to World War 1. The thermochemical equation for the reaction is shown below:

$$N_{2(g)} + 3H_{2(g)} \leftrightarrows 2NH_{3(g)} \quad \Delta H = -92kJ$$

The Haber process uses Le Chatelier's principle but is not run at a state of equilibrium.

a) Explain **the problem Haber faced when he used ONLY equilibrium principles** to try to synthesize ammonia commercially.

the reaction occurs extremely slowly ✓
(no ammonia in economically relevant time)

~~[2 marks]~~ 1

b) State and explain **two of the things** that Haber did to **allow the reaction to be commercially useful** (be SPECIFIC about conditions and why they worked to improve ammonia production)

high pressure (but not too high) - expensive
→ less moles of gas favoured
high temperature → RATE of production increased
remove NH3(g) → system continues to shift right
catalyst → faster rate at lower temp

[4 marks]

✓ change ✓ why
✓

15. Titanium (IV) oxide is one of the most commonly used paint pigments (colouring material) in the world with a wide range of applications including paint, sunscreen and food colouring. It is, for example, the pigment in most white paints used for outdoor applications such as road lines and buildings.

Considering the following equilibrium information, **explain why this pigment is a good choice** for white outdoor paints.

$$TiO_{2(s)} \rightleftharpoons Ti^{4+}_{(aq)} + 2O^{2-}_{(aq)} \quad K_{eq} = 1.5 \times 10^{-18}$$

✓ Keq is very low so the equilibrium position is to left
↳ the $TiO_{2(s)}$ won't dissolve in water
✓ (rain, snow) so will last a long time

[2 marks]

EXTRA SPACE for continuations or corrections
(make sure you indicate which question you are continuing or correcting)

Chemist:_____

Thursday May 18th, 2023 PERIOD 4

SCH 4U1 UNIT 3 Test 2
Chemical Systems and Equilibrium

Knowledge & Understanding:	/12
Thinking and Investigation	/11
Communication:	/13
Application:	/9

Knowledge & Understanding: **[12 marks]**

Answer the following multiple choice questions by selecting the BEST answer for each question. Be sure to record your selection in the table below as only the Answer Grid will be evaluated.

MULTIPLE CHOICE ANSWER GRID

Clearly indicate your answer in the grid below.

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

1. A solution of acid P has a pH of 6 and a solution of acid Q has a pH of 5. Determine the **correct statement.**

   A. Acid P is stronger than acid Q
   B. Acid Q is stronger than acid P
   C. The concentration of acid Q is higher that the concentration of Acid P
   D. The concentration of H^+ ions in the solution of Q is higher than in P
   E. The concentration of H^+ ions in the solution of P is higher than in Q

2. Identify the acid and conjugate base in the following reaction:

$$HSO_4^-{}_{(aq)} + HCO_3^-{}_{(aq)} \rightarrow SO_4^{2-}{}_{(aq)} + H_2CO_{3(aq)}$$

	acid	conjugate base
A.	$HCO_3^-{}_{(aq)}$	$H_2CO_{3(aq)}$
B.	$HSO_4^-{}_{(aq)}$	$HCO_3^-{}_{(aq)}$
C.	$HSO_4^-{}_{(aq)}$	$SO_4^{2-}{}_{(aq)}$
D.	$H_2CO_{3(aq)}$	$SO_4^{2-}{}_{(aq)}$
E.	$H_2CO_{3(aq)}$	$SO_4^{2-}{}_{(aq)}$

3. What is the concentration of OH^- ions in an aqueous solution in which $[H^+] = 2.0\times10^{-4}$ mol /L?

   A. 2.0×10^{-4} mol /L
   B. 4.0×10^{-8} mol /L
   C. 2.0×10^{-18} mol /L
   D. 1.0×10^{-10} mol /L
   E. 5.0×10^{-11} mol /L

4. When equal volumes of four 0.1 mol dm^{-3} solutions are arranged in order of increasing pH (highest pH first), what is the correct order?

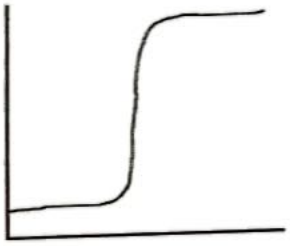
   A. $HClO_4 < CH_3COOH < CH_3NH_2 < LiOH$
   B. $CH_3COOH < HClO_4 < CH_3NH_2 < LiOH$
   C. $CH_3COOH < HClO_4 < LiOH < CH_3NH_2$
   D. $HClO_4 < CH_3NH_2 < CH_3COOH < LiOH$
   E. $CH_3NH_2 < HClO_4 < CH_3COOH < LiOH$

5. A scientist wishes to make a buffer with pH 3.5. The following is a list of acids available to make a buffer solution. Select the best acid to make the buffer solution.

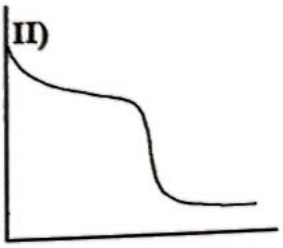
	Compound	K_a
A	Hydrochloric acid (HCl)	N/A
B	Hydrofluoric acid (HF)	6.6×10^{-4}
C	Ethanoic (acetic) acid (CH_3COOH)	1.8×10^{-5}
D	Hypochlorous acid (HClO)	2.9×10^{-8}
E	Boric acid (H_3BO_3)	5.8×10^{-10}

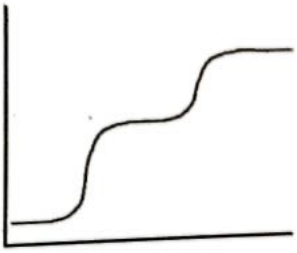
6. Based on the titration curves shown below, choose the substances **most likely to be the unknowns** in the following titrations.

I)



II)





	I	II	III
A	$HClO_4$	NaOH	NH_3
B	H_2SO_4	NH_3	$HClO_4$
C	NaOH	$HClO_4$	H_2SO_4
D	$HClO_4$	NH_3	H_2SO_4
E	H_2SO_4	NaOH	$HClO_4$

Short Answer:

7. a) Write a chemical equation that uses the **Arrhenius theory** to show what happens to **CH_3COOH** when it is placed in water (made aqueous). [1 mark]

$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$

– 0.5 com not equilibrium – or no states

b) Explain why **$CH_3NH_{2(aq)}$** acts as a **Bronsted-Lowry base** but not an Arrhenius base. Write the chemical equation to show how **$CH_3NH_{2(aq)}$** acts as a Bronsted-Lowry base.

✓ $CH_3NH_{2(aq)} + H_2O_{(l)} \rightleftharpoons CH_3NH_3^+{}_{(aq)} + OH^-_{(aq)}$

✓ it can't dissociate to produce OH^-, but it can accept a proton from H_2O to create OH^-

[2 marks]

Name: _____

Thursday May 18, 2023 PERIOD 4

b) Determine whether a solution with pH 6.80 at 50°C is **acidic, basic or neutral**. The K_w for water at 50°C is 5.50×10^{-14} [2 marks]

other logic OK too

✓ work $pK_w = 13.26$

$pH + pOH = pK_w$

✓ when neutral $pH = pOH$

conclusion: neutral $pH = 6.63$

pH > neutral ∴ basic

or $[H^+] = 10^{-pH} = 10^{-6.80} = 1.58 \times 10^{-7}$

$[H^+][OH^-] = 5.50 \times 10^{-14}$

$[OH^-] = 5.50 \times 10^{-14} / 1.58 \times 10^{-7}$

$[OH^-] = 3.47 \times 10^{-7}$

$[H^+] < [OH^-]$ ∴ basic

(8 marks)

Thinking and Inquiry

8. Equal volumes of three 1.00mol/L acid solutions (HX, HY, HZ) were reacted with calcium carbonate. Solution HZ was the most reactive and solution HY was the least reactive. Use this information to **identify the acids** in the table below. **Explain** your reasoning [2 marks]

HZ	$K_a = 7.5 \times 10^{-2}$
HX	$K_a = 3.5 \times 10^{-3}$
HY	$pK_a = 4.1$

✓ stronger acids have higher Ka/lower pKa. ✓

stronger acids react more quickly than weak.

9. A pharmacist **titrates 10.0 mL of 0.250mol/L warfarin ($C_{15}H_{17}O_2COOH_{(aq)}$) with 0.205 mol/L $KOH_{(aq)}$.** (The K_a for warfarin is 3.63×10^{-5})

a) Determine the **volume of titrant required** to reach the equivalence point. [1 mark]

$C_{H^+} \cdot V_{H^+} = C_{OH^-} \cdot V_{OH^-}$

$(0.250)(0.0100) = (0.205) V_{OH^-}$

$V_{OH^-} = 12.2\ mL$

b) Determine the **initial pH of the sample** (before any titrant is added). [4 marks]

$C_{15}H_{17}O_2COOH \rightleftharpoons C_{15}H_{17}O_2COO^- + H^+$

I	0.250	0	0
C	− ☺	+ ☺	+ ☺
E	0.250 − ☺	+ ☺	+ ☺

$K_a = \frac{[H^+][C_{15}H_{17}O_2COO^-]}{[C_{15}H_{17}O_2COOH]}$

$3.6 \times 10^{-5} = \frac{(☺)^2}{0.250 - ☺}$

$\frac{0.250}{3.6 \times 10^{-5}} >> 500$ assume $0.25 - ☺ = 0.250$

$3.6 \times 10^{-5} = \frac{☺^2}{0.250}$

☺ $= 3.00 \times 10^{-3}$

$\frac{3.00 \times 10^{-3}}{0.25} \times 100 = 1.2\%$ ✓ valid

$[H^+] = 3.00 \times 10^{-3}$

$pH = -\log[H^+]$ ✓

$= -\log(3.00 \times 10^{-3})$

$= 2.52$ 2sf Ka

c) Determine the **pH limit/final pH of the titration** [1 mark] ✓

pH of OH^- $pOH = \log(0.205) = 0.6882$

$pH = 14 - pOH = 13.318$ 3sf from [ ]

Name: _____

Thursday May 18, 2023 PERIOD 4

b) Determine whether a solution with pH 6.80 at 50°C is **acidic, basic or neutral**. The K_w for water at 50°C is 5.50×10^{-14} [2 marks]

other logic OK too

✓ work: $pKw = 13.26$

$pH + pOH = pKw$

✓ when neutral $pH = pOH$

conclusion: neutral pH = 6.63

pH > neutral ∴ basic

or $[H^+] = 10^{-pH} = 10^{-6.80} = 1.58 \times 10^{-7}$

$[H^+][OH^-] = 5.50 \times 10^{-14}$

$[OH^-] = 5.50 \times 10^{-14} / 1.58 \times 10^{-7}$

$[OH^-] = 3.47 \times 10^{-7}$

$[H^+] < [OH^-]$ ∴ basic

Thinking and Inquiry (8 marks)

8. Equal volumes of three 1.00mol/L acid solutions (HX, HY, HZ) were reacted with calcium carbonate. Solution HZ was the most reactive and solution HY was the least reactive. Use this information to **identify the acids** in the table below. **Explain** your reasoning [2 marks]

HZ	$K_a = 7.5 \times 10^{-2}$
HX	$K_a = 3.5 \times 10^{-3}$
HY	$pK_a = 4.1$

✓

stronger acids have higher Ka/lower pKa. ✓

stronger acids react more quickly than weak.

9. A pharmacist **titrates 10.0 mL of 0.250mol/L warfarin ($C_{15}H_{17}O_2COOH_{(aq)}$) with 0.205 mol/L $KOH_{(aq)}$.** (The K_a for warfarin is 3.63×10^{-5})

a) Determine the **volume of titrant required** to reach the equivalence point. [1 mark]

$C_{H^+} \cdot V_{H^+} = C_{OH^-} \cdot V_{OH^-}$

$(0.250)(0.0100) = (0.205) V_{OH^-}$

$V_{OH^-} = 12.2$ mL

b) Determine the **initial pH of the sample** (before any titrant is added). [4 marks]

$C_{15}H_{17}O_2COOH \rightleftharpoons C_{15}H_{17}O_2COO^- + H^+$

	$C_{15}H_{17}O_2COOH$	$C_{15}H_{17}O_2COO^-$	H^+
I	0.250	0	0
C	− ☺	+ ☺	+ ☺
E	0.250 − ☺	+ ☺	+ ☺

$K_a = \frac{[H^+][C_{15}H_{17}O_2COO^-]}{[C_{15}H_{17}O_2COOH]}$

$3.6 \times 10^{-5} = \frac{☺^2}{0.250 - ☺}$

$\frac{0.250}{3.6 \times 10^{-5}} >> 500$ assume $0.25 - ☺ = 0.250$

$3.6 \times 10^{-5} = \frac{☺^2}{0.250}$

☺ $= 3.00 \times 10^{-3}$

$\frac{3.00 \times 10^{-3}}{0.25} \times 100 = 1.2\%$ ✓ valid

$[H^+] = 3.00 \times 10^{-3}$

$pH = -\log [H^+]$ ✓

$= -\log(3.00 \times 10^{-3})$

$= 2.52$ 2sf Ka

c) Determine the **pH limit/final pH of the titration** [1 mark]

pH of OH^- $pOH = \log(0.205) = 0.6882$ ✓

$pH = 14 - pOH = 13.318$ 3sf from [ ]

Name: _____

Thursday May 18, 2023

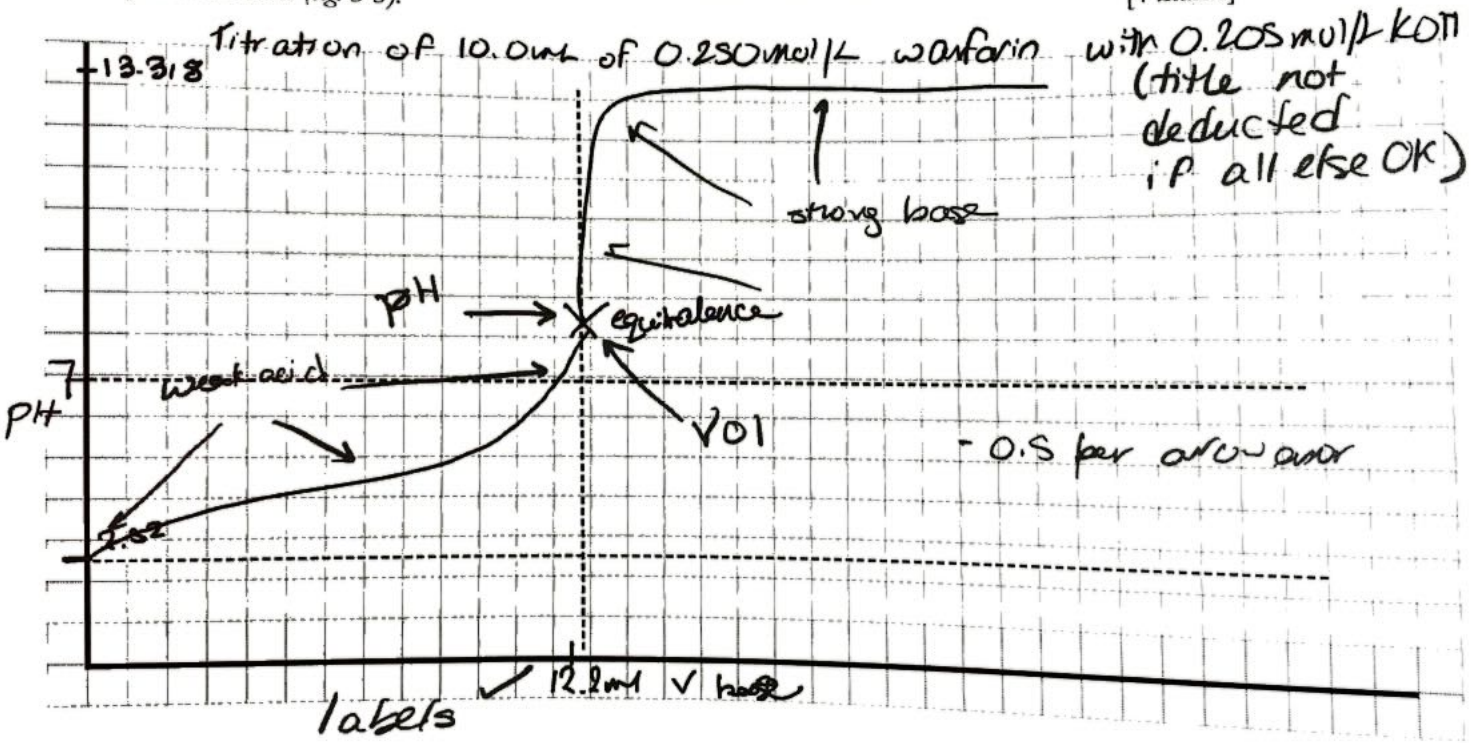
Communication **[8 marks]**

Question 9 continued…….

d) State the **approximate pH at the equivalence point** of the warfarin /KOH titration. **Explain your answer**. *You do not need to solve for the exact pH.* [2 marks]

$C_{19}H_{17}O_2COO^-K$ $C_{19}H_{17}O_2COO^-$ is conj. base of weak acid : pH >7
K^+ is from conj acid of strong base - is not an acid
pH = 7 overall pH >7

e) Use the information you obtained from questions a)- d) to **draw a titration curve to represent** the dimethylamine /HBr titration.
If you did not obtain a value for any of the parts above, draw your curve with "made up" numbers that are consistent with the kind of titration this is (e.g. S-S). [4 marks]



Overall - significant figures, clarity of responses, and neatness / organization _____ [2 marks]

SCH 4U1 – Unit 3 Test 2

Name: _____

Thursday May 18, 2023

Application **[10 marks]**

10. A buffer is created using **ammonia (NH_3)** and **ammonium chloride (NH_4Cl).**

a) Write the equation for the **Bronsted-Lowry chemical equilibrium** that allows the system to act as a buffer. [1 mark]

$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+ + OH^-_{(aq)}$

b) Using your equation in part (a), explain **the effect on the pH of the buffer** if a small quantity of **HCl** is added to it. [3 marks]

HCl reacts with OH^-

System shifts right to minimize change.

$[OH^-]\uparrow \therefore [H^+]\downarrow$ and pH ↑ but not as much as in an unbuffered system.

c) 1.00L of a buffer with concentrations of 0.550 mol/L NH_3 and 0.650 mol/L NH_4Cl has **0.200 mol of NaOH added** to it (without changing the volume). **Determine the pH of the buffer** AFTER the NaOH has been added. [3 marks]

	$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ ✓
I	0.550 mol/L 0.650 mol/L
C	+0.200 ✓ −0.200
E	0.750 mol/L 0.450 mol/L

$pH = pKa + \log \frac{[NH_3]}{[NH_4^+]}$ from green sheet

$pH = -\log(5.6\times10^{-10}) + \log\left(\frac{0.450}{0.750}\right)$ ✓

$pH = 9.47$

2sf from Ka

11. An aqueous equilibrium exists between carbon dioxide and carbonic acid.

$$H_2O_{(l)} + CO_{2(g)} \leftrightharpoons H_2CO_{3(aq)} \leftrightharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)} + \text{energy}$$

a) Use this equation to **explain why** the pH of regular rain is approximately 5.5. [1 mark]

$CO_{2(g)}$ in air forms carbonic acid which shifts both equilibria to the right giving some H^+.

b) Carbon dioxide is added to soda pop (to make it fizzy). Warm pop has a different taste/flavor to cold pop. Use the **equilibrium above** and your knowledge of **properties of acids and bases** to **predict the change in taste. Explain** your answer. [2 marks]

since the second equilibrium is exothermic increasing energy will shift to left, decreasing $[H^+]$ since acids taste sour, this means warm pop will taste less sour

↳ if H_2CO_3 used (∴ more sour)

give 1.5/2

Chemist:_____

SCH 4U1 UNIT 3 Test 2

Chemical Systems and Equilibrium

OF learning **Thursday May 18, 2023**

Knowledge & Understanding:	/12
Thinking and Investigation:	/8
Communication:	/8
Application:	/10

Period 5

Knowledge & Understanding: **[12 marks]**

Answer the following multiple choice questions by selecting the BEST answer for each question. Be sure to record your selection in the table below as only the Answer Grid will be evaluated.

MULTIPLE CHOICE ANSWER GRID

Clearly indicate your answer in the grid below.

1.	A	B	C	D	E	*4.*	A	B	C	D	E
2.	A	B	C	D	E	*5.*	A	B	C	D	E
3	A	B	C	D	E	*6.*	A	B	C	D	E

1. A solution of acid P has a pH of 5 and a solution of acid Q has a pH of 3. Determine the **correct statement.**

   A. Acid P is stronger than acid Q
   B. Acid Q is stronger than acid P
   C. The concentration of acid Q is higher that the concentration of Acid P
   D. The concentration of H^+ ions in the solution of P is higher than in Q
   E. The concentration of H^+ ions in the solution of Q is higher than in P

2. What is the concentration of H^+ ions in an aqueous solution in which $[OH^-] = 2.0\times10^{-4}$ mol /L?

   A. 5.0×10^{-11} mol /L
   B. 4.0×10^{-8} mol /L
   C. 2.0×10^{-18} mol /L
   D. 1.0×10^{-10} mol /L
   E. 2.0×10^{-4} mol /L

$\frac{1\times10^{-14}}{2\times10^{-4}}$ $0.\bar{3}$

3. What is the **pH** of the solution formed when ~~0.060~~ moles of KOH is added to a 1.00L solution of ~~0.050~~ mol/L HNO_3? *Assume no significant changes to the overall volume.*

   0.2

   0.1 mol KOH excess

   A. 2.00
   B. 7.00
   C. 12.00
   D. 13.00
   E. None of the above

   ∴

   pH = 14 − log(0.01)

4. A scientist wishes to make a buffer with pH 3.5. The following is a list of acids available to make a buffer solution. Select the best acid to make the buffer solution.

	Compound	K_a	pKa
A	Hydrochloric acid (HCl)	N/A	
B	Hydrofluoric acid (HF)	6.6×10^{-4}	3.18
C	Ethanoic (acetic) acid (CH_3COOH)	1.8×10^{-5}	4.74
D	Hypochlorous acid (HClO)	2.9×10^{-8}	much higher
E	Boric acid (H_3BO_3)	5.8×10^{-10}	

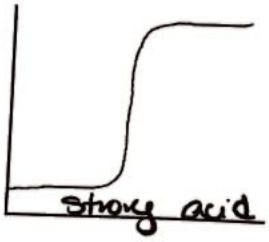
SCH 4U1 – Unit 3 Test 2

Name: _____

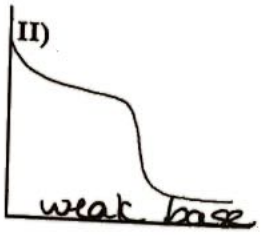
Thursday May 18, 2023

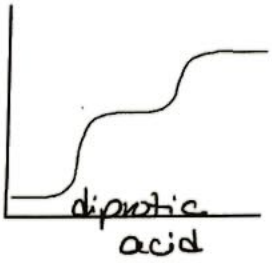
5. Based on the titration curves shown below, choose the substances **most likely to be the unknowns** in the following titrations.

I)



II)





	I	II	III
A	$NaOH$	$HClO_4$	NH_3
B	H_2SO_4	NH_3	$HClO_4$
C	$HClO_4$	H_2SO_4	$NaOH$
D	$HClO_4$	NH_3	H_2SO_4
E	H_2SO_4	$NaOH$	$HClO_4$

switched in final

6. When equal volumes of four 0.1 mol dm^{-3} solutions are arranged in order of decreasing pH (highest pH first), what is the correct order?

A. $CH_3COOH > HClO_4 > CH_3NH_2 > LiOH$
B. $LiOH > CH_3NH_2 > CH_3COOH > HClO_4$
C. $CH_3NH_2 > LiOH > HClO_4 > CH_3COOH$
D. $LiOH > CH_3COOH > CH_3NH_2 > HClO_4$

Short Answer:

7. a) Write a chemical equation that uses the **Arrhenius theory** to show what happens to **CH_3COOH** when it is placed in water (made aqueous). [1 mark]

$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$

– 0.5 com if not equilibrium

b) Use a chemical equation to show how **$CH_3NH_{2(aq)}$** acts as a **Bronsted-Lowry base** when it is placed in water (made aqueous) [1 mark]

(weak)

$CH_3NH_{2(aq)} + H_2O_{(l)} \rightleftharpoons CH_3NH_3^+{}_{(aq)} + OH^-_{(aq)}$

c) Identify the **acid and the conjugate base** in the equation you wrote for (b) [1 mark]

– 0.5 com no state

acid = H_2O conj. base = OH^-

8. a) Explain **why pH = 7 cannot always be used** as the definition of neutral. [1 mark]

water autoionizes in an equilibrium rxn and this is temperature dependent
∴ neutral pH is > 7 below 25°C and < 7 above 25°C

idea neutral pH at different temperatures is not the s

b) Determine whether a solution with pH 6.80 at 50°C is acidic, basic or neutral. The K_w for water at 50°C is 5.50 x 10^{-14} [2 marks]

other logic OK too

✓ work $pK_w = 13.26$
$pH + pOH = pK_w$
✓ when neutral $pH = pOH$
conclusion: neutral pH = 6.63
pH > neutral ∴ basic

or $[H^+] = 10^{-pH} = 10^{-6.80} = 1.58 \times 10^{-7}$
$[H^+][OH^-] = 5.50 \times 10^{-14}$
$[OH^-] = 5.50 \times 10^{-14} / 1.58 \times 10^{-7}$
$[OH^-] = 3.47 \times 10^{-7}$
$[H^+] < [OH^-]$ ∴ basic

Thinking and Inquiry **(8 marks)**

8. Equal volumes of three 1.00mol/L acid solutions (HA, HB, HC) were reacted with magnesium metal. Solution HC was the most reactive and solution HB was the least reactive. Use this information to **identify the acids** in the table below. **Explain** your reasoning [2 marks]

HC	$K_a = 7.5 \times 10^{-2}$
HA	$K_a = 3.5 \times 10^{-3}$
HB	$pK_a = 4.1$

1.25×10^{-4}

✓ most reactive = lowest pKa or highest Ka
HC > HA > HB ✓

9. A pharmacist **titrates 10.0 mL of 0.250mol/L lidocaine ($C_{14}H_{22}N_2O_{(aq)}$) with 0.205 mol/L $HBr_{(aq)}$.** (The K_b for lidocaine is 5.3 x 10^{-6})

a) Determine the **volume of titrant required** to reach the equivalence point. [1 mark]

$C_{H^+}V_{H^+} = C_{OH^-}V_{OH^-}$
$(0.250)(0.0100) = (0.205)V_{OH^-}$
$V_{OH^-} = 12.195$
$V_{OH^-} = 12.2\,mL$ 3sf −0.5 com

b) Determine the **initial pH of the sample** (before any titrant is added). [4 marks]

$C_{14}H_{22}N_2O + H_2O \rightleftharpoons C_{14}H_{22}N_2OH^+ + OH^-$

I	0.250	0	0
C	− ☺	+ ☺	+ ☺
E	0.250 − ☺	+ ☺	+ ☺

$K_b = \frac{[C_{14}H_{22}N_2OH^+][OH^-]}{[C_{14}H_{22}N_2O]}$
$5.3 \times 10^{-6} = \frac{☺^2}{(0.250 - ☺)}$ ✓

$\frac{0.250}{K} >> 500$
assume $0.25 - ☺ = 0.250$
$5.3 \times 10^{-6} = \frac{☺^2}{0.250}$

☺ $= 1.151 \times 10^{-3}$
$\frac{1.151 \times 10^{-3}}{0.25} \times 100\% = 0.5\%$ ✓ valid
$pOH = -\log(1.151 \times 10^{-3}) = 2.939$
$pH = 14 - 2.939$
$pH = 11.06$ ✓
2 sf (K_b)

c) Determine **the pH limit/final pH of the titration** [1 mark]

$pH = -\log[H^+]$
$pH = -\log(0.205)$
$pH = 0.688$
3 sf (conc)

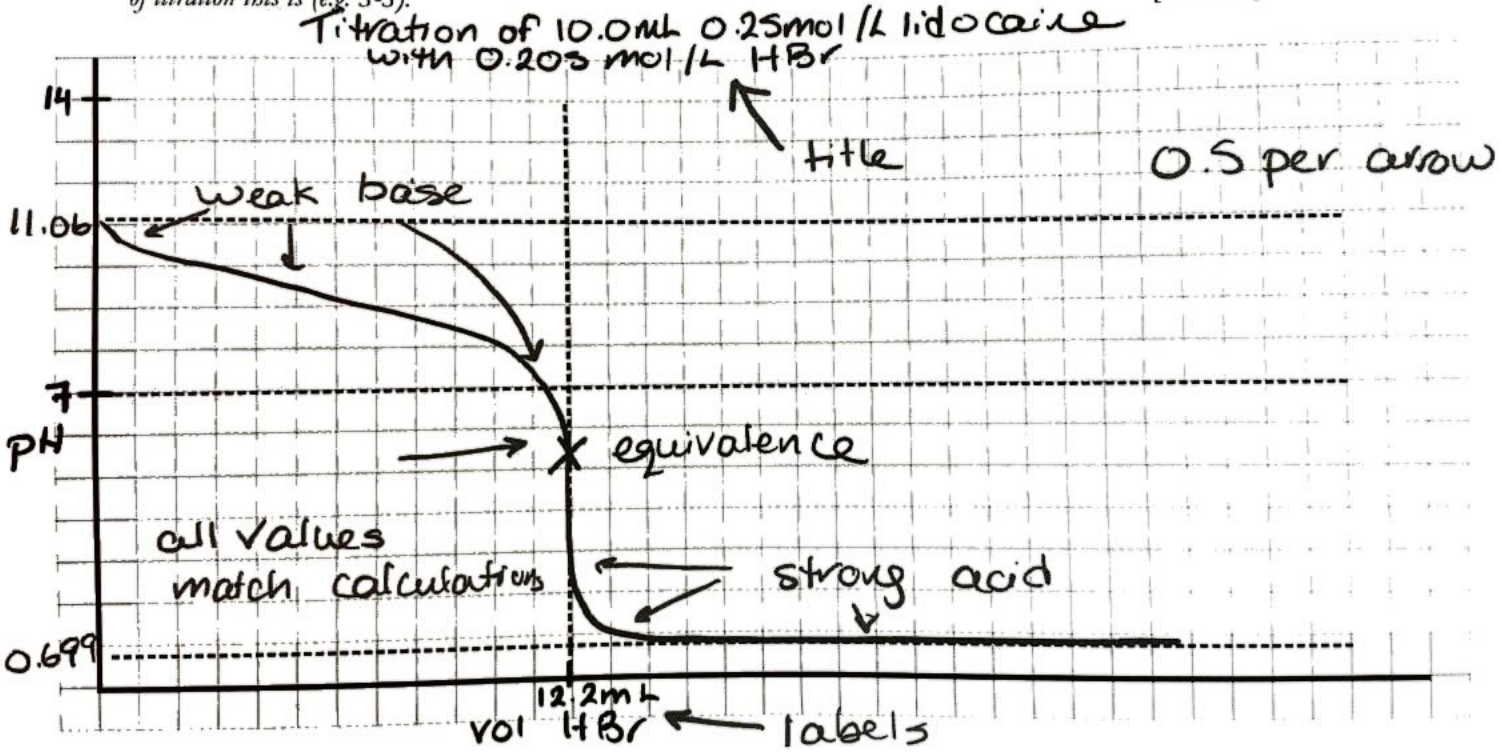
Communication **[8 marks]**

Question 9 continued…….

d) State the **approximate pH at the equivalence point** of the lidocaine /HBr titration. **Explain your answer.** *You do not need to solve for the exact pH.* [2 marks]

lidocaine is a weak base ∴ measurably weak conj acid pH<7
HBr is a strong acid ∴ unmeasurably weak c. base pH = 7
overall pH < 7

e) Use the information you obtained from questions a)- d) to **draw a titration curve to represent** the dimethylamine /HBr titration.
If you did not obtain a value for any of the parts above, draw your curve with "made up" numbers that are consistent with the kind of titration this is (e.g. S-S). [4 marks]



Overall - significant figures, clarity of responses, and neatness / organization _____ [2 marks]

SCH 4U1 – Unit 3 Test 2 Name: _____

Thursday May 18, 2023

Application **[10 marks]**

10. A buffer is created using **nitrous acid (HNO_2)** and **sodium nitrite ($NaNO_2$)**.

a) Write the equation for the **chemical equilibrium** that allows the system to act as a buffer. [1 mark]

BL

$HNO_{2(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + NO_2^-{}_{(aq)}$

b) Using your equation in part (a), explain **the effect on the pH of the buffer** if a small quantity of **NaOH** is added to it. [3 marks]

OH^- reacts with the H_3O^+ and system shifts right to minimize the change. ✓
pH will increase but less than in an unbuffered system ✓

c) 1.00L of a buffer with concentrations of 0.550 mol/L HNO_2 and 0.650 mol/L $NaNO_2$ has **0.200 mol of HCl added** to it (without changing the volume). **Determine the pH of the buffer** AFTER the HCl has been added. [3 marks]

	HNO_2	$\rightleftharpoons$	NO_2^-	+	H^+
I	0.550 mol/L		0.650 mol/L		
C	+0.200		−0.200		
E	+0.750 mol/L		+0.450 mol/L		

$pH = pKa + \log \frac{[NO_2^-]}{[HNO_2]}$

green sheet

$pH = -\log(4.0\times10^{-4}) + \log\frac{(0.450)}{(0.750)}$ ✓

$pH = 3.18$ ✓

2sf (Ka)

11. An aqueous equilibrium exists between carbon dioxide and carbonic acid.

$$H_2O_{(l)} + CO_{2(g)} \leftrightarrows H_2CO_{3(aq)} \leftrightarrows H^+_{(aq)} + HCO_3^-{}_{(aq)} + \text{energy}$$

a) Use this equation to **explain why** the pH of regular rain is approximately 5.5. [1 mark]

$CO_{2(g)}$ in air dissolves in water to form carbonic acid, which dissociates partially to give $[H^+]$ > than neutral.

b) Carbon dioxide is added to soda pop (to make it fizzy). Warm pop has a different taste/flavor to cold pop. Use the **equilibrium above** and your knowledge of **properties of acids and bases** to **predict the change in taste. Explain** your answer.

[2 marks]

energy will shift equilibrium left, (decreasing $CO_{2(g)}$ solubility) since $[H^+]$ is lower ✓
and acids taste sour, warm pop will taste sweeter than cold pop. ✓

UNIT 4 – Organic Chemistry –TEST 1
(Assessment of Learning)
Haynes

Chemist: _____
Tuesday May 30, 2023

Knowledge:	/ 11
Thinking & Investigation:	/ 10
Communication:	/ 8
Application:	/ 9

KNOWLEDGE

(11 marks)

For each of the following questions, record the ***best*** answer in the answer key provided.

MULTIPLE CHOICE – Answer Key

✓ 1	A	B	C	D	E	4	A	B	C	D	E
C → 2	A	B	C	D	E	5	A	B	C	D	E accept both
3	A	B	C	D	E						

1. Which statement about **butan-2-ol** and **hexan-2-ol** is correct?

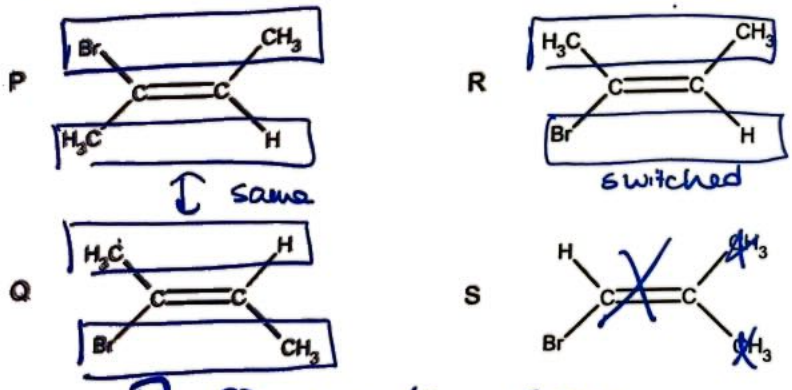
   A. They are structural isomers
   B. They have the same empirical formula.
   C. They are members of a homologous series
   D. They are unsaturated
   E. None of the above are correct

   B in find

2. Which of the following reactions represents **incomplete combustion of a hydrocarbon**?

   A. $C_3H_8 + 5\,O_2 \rightarrow 3\,CO_2 + 4\,H_2O$
   B. $C_3H_8O + 3\,O_2 \rightarrow CO_2 + CO + C + 4\,H_2O$
   C. $C_3H_8 + 4\,O_2 \rightarrow CO_2 + 2\,CO + C + 4\,H_2O$
   D. $2\,C_3H_8O + 9\,O_2 \rightarrow 6\,CO_2 + 8\,H_2O$
   E. Two of these answers are correct

3. Which two molecules are **E-Zs isomers** of each other?



   A. P and Q
   B. P and S
   C. Q and S
   D. R and S
   E. Q and R

P + Q are the same
so P/Q and R

UNIT 4 – Organic Chemistry Test 1
(Haynes)

Chemist: _____

Tuesday May 30, 2023

4. Which of the following is NOT a product of an addition reaction to but-1-ene?

A. butane ✗ H_2
B. 1-bromobutane → 2
C. butan-2-ol ✓
D. 2-bromobutane ✓
E. 1,2-diiodobutane ✓

5. Which of the following expanded molecular formulas has **cis-trans isomers**?

A. $CH_3CH_2CH_2CH_3$
B. $CH_3C(CH_3)CHCH_3$
C. $CH_3CH(CH_3)CH_2CH_3$
D. $CH_2CHCHCH_3$
E. $CH_3CCCH_2CH_3$

6. **Determine the molecular formula** of a 17-carbon (acyclic) hydrocarbon with 3 double bonds and one triple bond. Show your work. **(1 mark)**

$C_nH_{2n+2-2x-4y}$

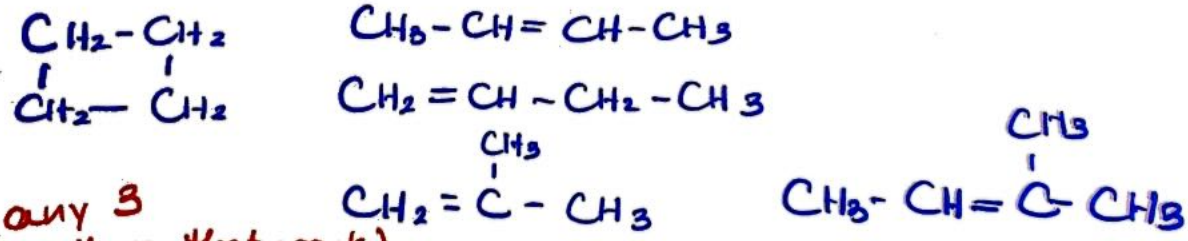
$n = 17$ $\quad 2(17)+2-2(3)-4(1) = 28$

$x = 3$ $\quad C_{17}H_{28}$ ✓

$y = 1$

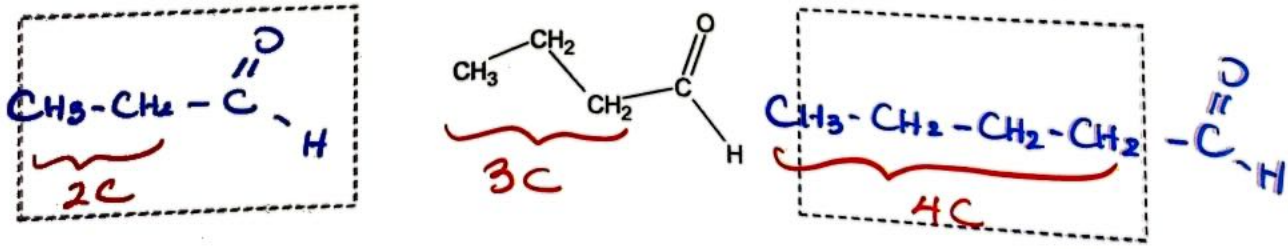
−0.5 if no work

7. **Use condensed structural diagrams** to draw three **structural isomers** of C_4H_8 **(3 marks)**



any 3
(or others that work)

8. The molecule shown below is butanal. Draw the member of the **homologous series** containing propanal that comes **before** it, and the member that comes **after** it. **(2 marks)**



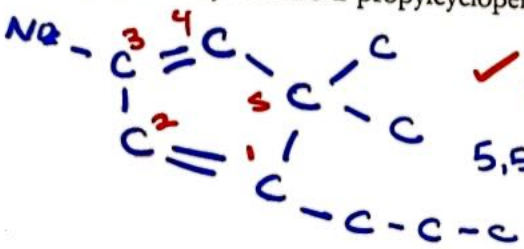
UNIT 4 – Organic Chemistry Test 1 Chemist: _____

(Haynes) Tuesday May 30, 2023

THINKING & INVESTIGATION **(10 marks)**

9. **Determine the error(s)** in the following name and **name the compound correctly.** *Note: show your work (1 mark awarded for process and error identification)*

1,1-dimethyl-4-nitro-2-propylcyclopenta-2,4-diene **(2 marks)**



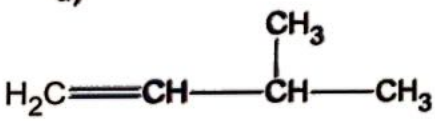
✓ error - double bonds not given priority when numbering ring

5,5-dimethyl-3-nitro-1-propylcyclopenta-1,3-diene ✓

10. **Complete the following reactions including special conditions** (if required) **and inorganic reactants.**
Use **the type of diagram specified.**
Names of structures are **NOT** required.

(2T each - total 8 marks)
(2C marks for diagram type)

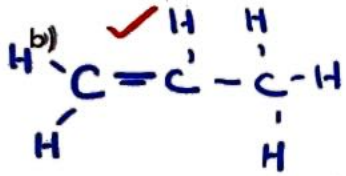
a)



$+ Cl_2$ ✓ ⟶ $CH_2(Cl)CH(Cl)CH(CH_3)CH_3$ ✓

(expanded molecular formula)

b)

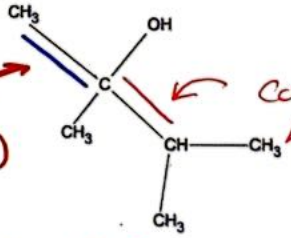


✓ $+ H_2$ ✓ ⟶ high pressure, Δ, Ni/Pt/Pd ⟶ $H_3C—CH_2—CH_3$

(full structural diagram)

c)

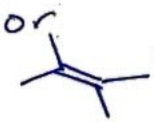
✓ $+ H_2O$ ⟶ 6 mol/L H^+ ✓ ⟶



must be here (Markovnikov)

could be here too

or

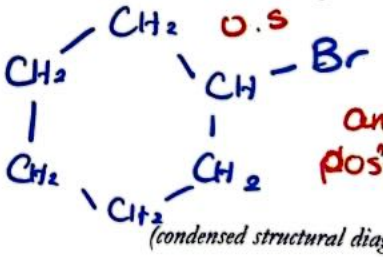


(line diagram)

d)

+ Br2 ⟶ hν ✓ ⟶

(limited)



o.s

any pos'n

o.s

+ HBr

(condensed structural diagram)

UNIT 4 – Organic Chemistry Test 1
(Haynes)

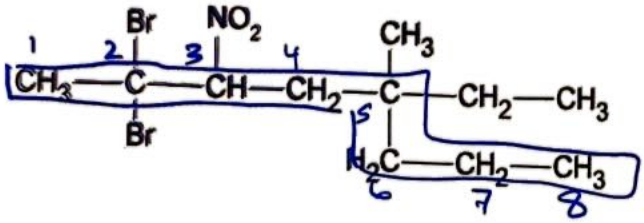
Chemist: _____

Tuesday May 30, 2023

COMMUNICATION **(8 marks)**

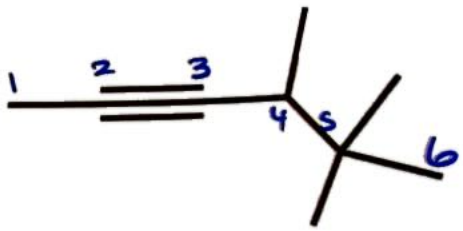
11. Name the following molecules using their scientific (IUPAC) names and common name where required. **(6 marks maximum)** ** there are 7 marks available – you are allowed up to one mark of "free" error(s)*

a)



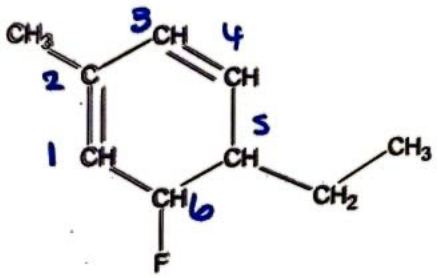
2,2-dibromo-5-ethyl-5-methyl-3-nitrooctane

b)



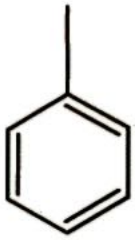
4,5,5-trimethylhex-2-yne

c)



5-ethyl-6-fluoro-2-methylcyclohexa 1,~~3-diene~~

d)



1-methylbenzene
(methylbenzene)

e) Common Name: toluene

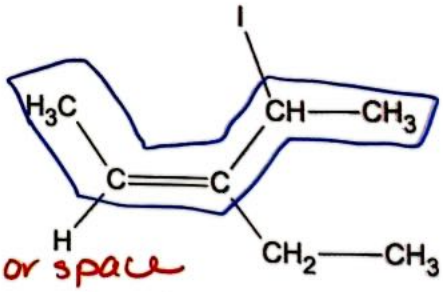
f) $CH_3CHCHC(CH_3)_2CH_2CCH$

4,4-dimethylhept-5-en-1-yne

$CH_3-CH=CH-C(CH_3)_2-CH_2-C\equiv CH$

7 6 5 4 1 3 2 1

g)



or space

cis-3-ethyl-4-iodopent-2-ene
(2Z)

12. **Correct diagram type** in question #10 reactions _____(2 marks)

UNIT 4 – Organic Chemistry Test 1
(Haynes)

Chemist: _____

Tuesday May 30, 2023

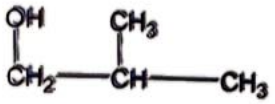
APPLICATION

(9 marks)

13. A scientist wishes to make **the compound below, and they decide to use 2-methylprop-1-ene** as a starting material. When they do the reaction the find out that most of the product produced is not the product they wanted. Identify **what the main product of the reaction IS and explain the error that the scientist made.** *You may include a diagram as part of your explanation if you wish to.*

(3 marks)

Product wanted:



$CH_2 = CH(CH_3) - CH_3$

more H less H

product $CH_2 - C(CH_3)(OH) - CH_3$

due to Markovnikov's rule the preferred product will have the OH on the second C

or explain with words

14. **Both olive oil and butter consist mainly of fats with hydrocarbon chains that are 18-20 carbons long. However, olive oil is a liquid at room temperature, and butter is a solid. Use your knowledge of the properties of hydrocarbons to explain this difference.** *You may include a diagram as part of your explanation if you wish to.*

(3 marks)

olive oil contains unsaturated hydrocarbon chains (C=C) so their packing is not as good as the chains in butter which are saturated (C–C only) better packing means stronger london dispersion forces so higher melting point /solid vs liquid at room temp.

✓ C=C vs C–C ✓ packing ✓ forces stronger

15. **A scientist finds samples of 3 unlabelled organic compounds in the freezer.** They do have melting points written on the bottles. **Bottle A says -138°C, bottle B says -125.7°C and bottle C says-78.5°C.** The freezer contents list says that there are samples of **ethane, butane and decane** in the freezer. Identify which sample is likely to be which and explain why.

(3 marks)

A: ethane B: butane C: decane

longer hydrocarbon chain - stronger London forces

∴ higher melting point

UNIT 4 – Organic Chemistry TEST 2
(Assessment of Learning)
(Haynes)

Chemist: _____

Wednesday June 7th, 2023

Knowledge:	/12
Thinking & Investigation:	/9
Communication:	/8
Application:	/10

KNOWLEDGE & UNDERSTANDING [12 marks]

For each of the following questions, record the ***best*** answer in the answer key provided.

MULTIPLE CHOICE – Answer Key

1	A	B	C	D	E	*4*	A	B	C	D	E
2	A	B	C	D	E	*5*	A	B	C	D	E
3	A	B	C	D	E	*6*	A	B	C	D	E

1. Which statement about members of a **homologous series** is correct?

A. Each member has the same empirical formula.
B. Each member differs in their degree of unsaturation.
C. Each member differs by a CH_2 group.
D. Each member possesses the same functional group
E. Two of the above are correct

both definitions

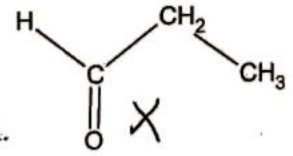
2. Which of the following are **structural isomers of $C_5H_{10}O$?**

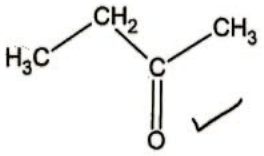
I. X-methylbutan-1-ol II. 2-methylbut-2-en-1-ol III. cyclopentanol

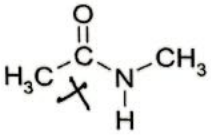
$C_5H_{12}O$

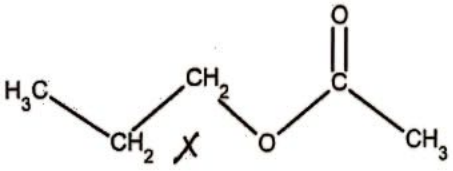
A. I only
B. II only
C. I and III only
D. II and III only
E. I, II and III

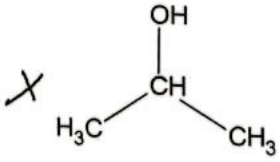
3. Which of the following represents a **ketone**?

A. 

B. 

C. 

D. 

E. 

4. Which compound is the **preferred product** of the addition of HBr to hex-1-ene?

A. $(Br)CH_2CH_2CH_2CH_2CH_2CH_2(Br)$
B. $CH_3CH_2CH_2CH_2CH_2CH_2(Br)$
C. $CH_3CH_2CH_2CH_2CH(Br)CH_3$
D. $CH_3CH_2CH_2CH_2C(Br)_2CH_3$
E. Both B and C are correct

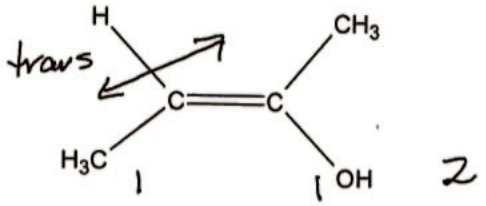
UNIT 4 – Organic Chemistry Test 2 Chemist: _____
(Haynes) Wednesday June 7th, 2023

5. Which of the following compounds are **aromatic hydrocarbons**?

I. TNT ✓ II. 3-methylcyclohexene ✗ III. xylene ✓

A. I and III
B. I and II
C. II and III
D. I, II and III
E. only one of the above is aromatic

6. Assign the correct terms to the structure shown below:



A. cis, Z
B. cis, E
C. trans, Z
D. trans, E

7. Explain what is meant by a **functional group** on an organic compound. **(2)**

✓ a group of atoms (or atom) that affects (causes) ✓ the physical and chemical properties of the compound

8. The following two-step reaction was carried out.

$C_3H_6 \xrightarrow{\text{I}} C_3H_8 \xrightarrow{\text{II}} C_3H_7Br$

a) Identify the name of the **type of reaction and special conditions** in each step **(4)**

Step	Name of Reaction Type	Special Conditions
I	hydrogenation ✓ (addition)	heat, high pressure ✓, Ni/Pt/Pd
II	halogenation – substitution ✓ (both)	hν

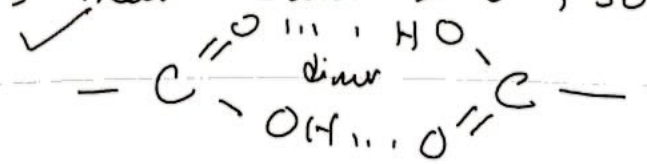
THINKING AND INVESTIGATION **[9 marks]**

9. Arrange the following compounds in order of **increasing melting point.** **Explain** your answer.

Butanal butan-2-ol butanoic acid **(4)**

✓ butanal < butan-2-ol < butanoic acid

butanal is polar but intermolecular forces are dipole-dipole attractions, which are weaker than hydrogen bonds in both butan-2-ol and butanoic acid. Butanoic acid forms dimers (see below) so more H-bonds than butan-2-ol, so it has highest mp ✓



Chemist: _____

Wednesday June 7th, 2023

10. Three **different** compounds (A, B and C) with the **molecular formula $C_4H_{10}O$** are reacted with limited amounts of acidified potassium dichromate (**$K_2Cr_2O_7$**).

ONLY the **products from the reactions** that DO occur are reacted with acidified potassium permanganate (**$KMnO_4$**). The results of these reactions are shown in the chart below

Initial Compound	First reaction: limited $K_2Cr_2O_7$ /H^+ (distillation)	Second reaction: $KMnO_4$ / H^+ (reflux)
A	reaction	no reaction
B	no reaction	*not reacted*
C	reaction	reaction

a) Based on the information above, draw the **structural formulas of compounds A, B and C** using condensed structural diagrams. **(3)**

A: $CH_3-CH(OH)-CH_2-CH_3$ ✓

B: $CH_3-C(CH_3)_2-OH$ ✓

C: $CH_3-CH_2-CH_2-CH_2-OH$ ✓ both are 1° only need one

or $CH_3-CH(CH_3)-CH_2-OH$

Explain your reasoning for the structures you determined in (a) **(2)**

Since B does not react it must be a 3° alcohol ✓ ✓ overall

A reacts once but not again - must be a 2° alcohol

C reacts twice (aldehyde → carboxylic acid) so must be 1° alcohol

Space for rough work. **Work here will only be marked if you write "please mark" beside it.**

UNIT 4 – Organic Chemistry Test 2
(Haynes)

Chemist: _____

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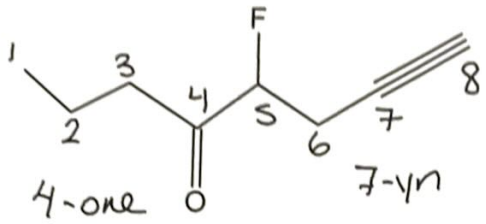
COMMUNICATION

[8 marks]

12. Use proper IUPAC naming conventions to name the following structures. IF SPECIFIED also give the common name. *There are 7 marks available – you get up to one "free" error*

(6)

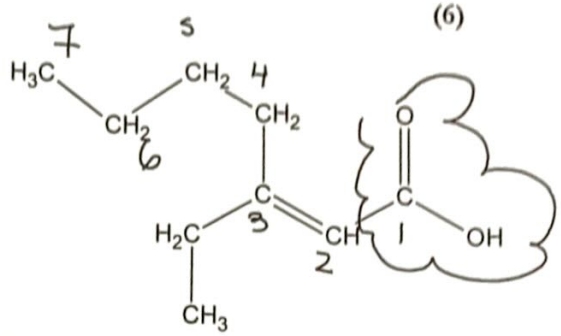
(a)



4-one 7-yn

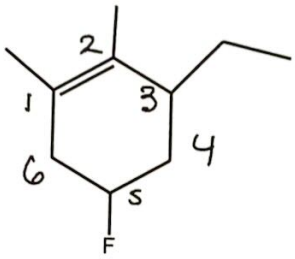
5-fluorooct-7-yn-4-one

(b)



3-ethylhept-2-enoic acid

(c)



3-ethyl-5-fluoro-1,2-dimethylcyclohex-1-ene (cyclohexene ok)

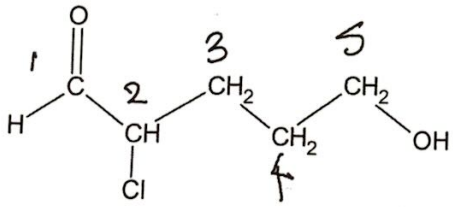
(d)

HOOCCOOH

IUPAC: ethanedioic acid

Common: oxalic acid

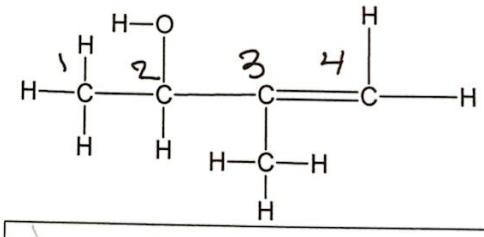
(e)



2-chloro-5-hydroxypentanal

(f)

2-ol



3-methylbut-3-en-2-ol

Correct types of diagram, showing work etc. _____ (2 marks)

Chemist: _____

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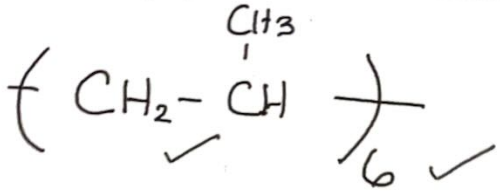
APPLICATION **[10 marks]**

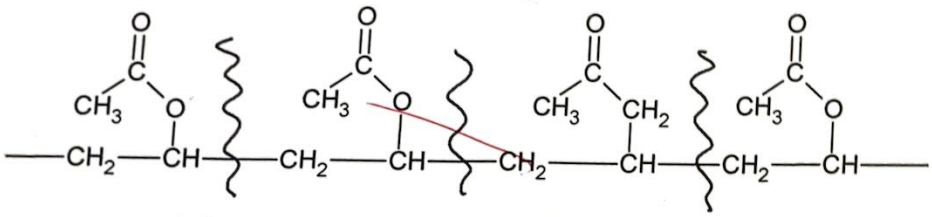
13. Write the **polymer notation** for a section of **polypropene** containing 6 monomers.



(2)

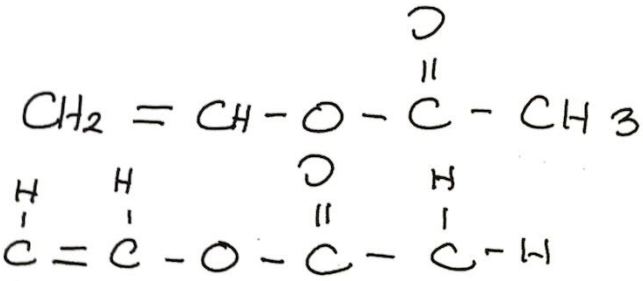
full structural OK too

14. Polyvinyl acetate (PVA) is used as an adhesive for porous materials like wood, paper, and cloth. It is the polymer used in white glue, school glue and wood glue. A section of PVA is shown below.



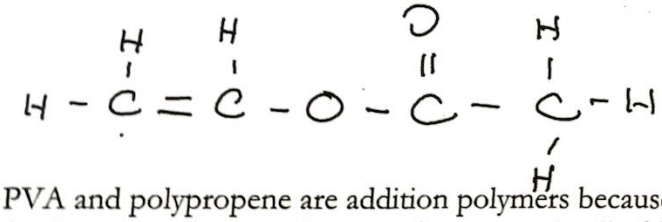
a) Draw the **structure** of **the monomer** used to make PVA using a **full or condensed structural diagram.**

(2)



-0.5 per error

or



c) Both PVA and polypropene are addition polymers because of the type of reaction used to create them. State the **functional group** that must be present in all addition polymers and **explain why the type of reaction is called an "addition" reaction.** (2)

C=C required

addition because all atoms are included in the product (no side/other products)

d) Some polymers are flexible, and some are rigid. **Explain how the rigidity of a polymer can be increased.** (2)

increase # (covalent) crosslinks between different polymer chains

15. Two types of paint are used to paint walls of buildings – **latex paint and oil paint.** Latex paint contains **polar pigment (colour) particles** dissolved in water and oil paint contains **nonpolar pigment particles** dissolved in a nonpolar solvent. When the paint dries only the dry pigments are left on the wall.

If you paint latex paint directly over oil paint it will not stick (it will peel off when dry) so it is important to know what kind of paint is already on a wall before painting over it.

A common "home test" is to use a cotton ball **soaked with rubbing alcohol (propan-2-ol)** to wipe a clean section of your painted wall.

Using your understanding of the **properties of rubbing alcohol and those of the pigments in each of the types of paint**, state **what type of paint pigment** would **come off the wall** when tested and **explain why.**

(2)

propan-2-ol is a polar solvent, therefore can form dipole (dipole or H-bond attractions with the latex pigment and dissolve them (paint comes off the wall)
the nonpolar oil paint pigment won't dissolve. (not strictly required)

Extra space for continuations or corrections