ChemiCo 2018 – Question Booklet

Read these instructions carefully

• There are 3 parts in this test to be completed in 120 minutes. Manage your time accordingly.
• Shade your Part A answers in the answer sheet provided below. You can leave questions unanswered to avoid penalty for wrong answers.
• For Parts B and C all answers must be written in the appropriate boxes. Any other space can be used for draft work. Only answers inside appropriate boxes will be graded.
• You can use your own scientific calculator. Use of smartphones is strictly prohibited.
• Very important note (!) Write your name on every page of the question booklet.

No. of Questions Points for Each Question 60 Points Total
| Part A | 20 multiple choice questions | 1.5 p for correct answer -0.5 p for incorrect answer | 30 points |
| Part B | 8 short questions | 1.5 – 4 points | 20 points |
| Part C | 2 long questions | 5 points | 10 points |

Full Name: ______________________________________
School: ___________________________ Country: _____________

<table>
<thead>
<tr>
<th>Part A</th>
<th>Part B</th>
<th>Part C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shade your answers below</td>
<td>(For examiners’ use)</td>
<td>(For examiners’ use)</td>
</tr>
<tr>
<td>1. A B C D</td>
<td>/4</td>
<td>1.</td>
</tr>
<tr>
<td>2. A B C D</td>
<td>/3</td>
<td>2.</td>
</tr>
<tr>
<td>3. A B C D</td>
<td>/3</td>
<td>3.</td>
</tr>
<tr>
<td>5. A B C D</td>
<td>/3</td>
<td>5.</td>
</tr>
<tr>
<td>6. A B C D</td>
<td>/1.5</td>
<td>6.</td>
</tr>
<tr>
<td>8. A B C D</td>
<td>/1.5</td>
<td>8.</td>
</tr>
<tr>
<td>10. A B C D</td>
<td>/</td>
<td>10.</td>
</tr>
</tbody>
</table>

/ 30 / 20 / 10

Total Score: / 60
PART A

1. An equimolar mixture of hydrogen and chlorine gases is reacted in a tube sealed with a rubber stopper, causing the rubber stopper to shoot out. Which of the following can explain this incident?

I. The amount of gases increased
II. The pressure increased
III. The reaction is exothermic

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

2. “It is better to prevent waste, rather than clean it up” is one of the Twelve Principles of Green Chemistry. Waste can be in the form of unreacted starting material or produced by-product.

Which of the following processes of obtaining methane is the least “green”, assuming all reactions go to completion?

A. Al₄C₃ + 12H₂O → 3CH₄ + 4Al(OH)₃
B. CH₃Br + H₂ → CH₄ + HBr
C. CH₃COONa + NaOH → CH₄ + Na₂CO₃
D. CO + 3H₂ → CH₄ + H₂O

3. In our universe there are 2 and 8 electrons in the 1st and 2nd shells, respectively. Consider a hypothetical universe with 3 and 9 electrons in the 1st and 2nd shells, respectively. What is the most likely ion that would form for an element X with atomic number 11 in that universe?

A. X²⁻   B. X⁻   C. X⁺   D. X²⁺

4. One mole of calcium carbonate requires 175 kJ of heat to decompose into calcium oxide and carbon dioxide. Which of the following equations represents the formation of one mole of calcium carbonate from calcium oxide and carbon dioxide?

A. CaCO₃(s) → CaO(s) + CO₂(g) + 175 kJ/mol
B. CaCO₃(s) + 175 kJ/mol → CaO(s) + CO₂(g)
C. CaO(s) + CO₂(g) → CaCO₃(s) + 175 kJ/mol
D. CaO(s) + CO₂(g) + 175 kJ/mol → CaCO₃(s)
5. Consider the following information regarding carbon-carbon bonds.

<table>
<thead>
<tr>
<th></th>
<th>C-C</th>
<th>C≡C</th>
<th>C≡C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond type</td>
<td>1 sigma</td>
<td>1 sigma and 1 pi</td>
<td>1 sigma and 2 pi</td>
</tr>
<tr>
<td>Bond length</td>
<td>0.154 nm</td>
<td>0.133 nm</td>
<td>0.120 nm</td>
</tr>
<tr>
<td>Bond energy</td>
<td>346 kJ/mol</td>
<td>610 kJ/mol</td>
<td>835 kJ/mol</td>
</tr>
</tbody>
</table>

Which of the following statements is wrong?

A. The shorter the bond the higher its energy

B. Pi bond is weaker than sigma bond

C. Pi bonds bring atoms closer

D. C=C and C≡C bonds are less reactive than C-C bond

6. In the past, alchemists sought to convert lead to gold, but never succeeded. Today, this process is possible through radioactive decay of unstable lead isotopes. How many protons would lead need to lose to turn into gold?

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

7. Litmus is a mixture of specific pH-sensitive dyes. When absorbed onto paper it is known as Litmus paper, which is commonly used to test acidity or alkalinity of a solution. Litmus paper is purple when placed in neutral solutions. It turns red when placed in acidic solutions and blue when placed in basic (alkaline) solutions.

Equal volumes of three unknown solutions A, B and C are mixed in different combinations and the color of the Litmus paper dipped into the resulting solution is shown below:

\[ A + B = \text{purple} \]
\[ B + C = \text{red} \]
\[ A + B + C = \text{blue} \]

What would the color of Litmus paper be, if it were dipped into the solution resulting from the following combination?

\[ A + C = ? \]

A. Red  B. Blue  C. Purple  D. Impossible to tell
8. Shown below is the density plot of water-ethanol mixtures at 20 °C. From the plot, pure water has a density of 1.0 g/ml, and pure ethanol has a density of 0.79 g/ml.

![Density Plot](image)

70 ml of absolute ethanol and 30 ml of pure water are mixed at 20 °C. What is the volume of the mixed solution?

A. 90 ml  
B. 98 ml  
C. 100 ml  
D. 108 ml

9. The bond dissociation energies of a C−H bond and C−F bond are 439 kJ/mol and 552 kJ/mol. What is the minimum energy required to break any of the bonds in fluoromethane (CH₃F)?

A. 439 kJ  
B. 552 kJ  
C. 7.3×10⁻²² kJ  
D. 9.2×10⁻²² kJ

10. Equal volumes of equally concentrated solutions of Ca(OH)₂ and HCl are mixed. What is the relative ratio of ion concentrations in the resulting solution?

A. [OH⁻] = [Ca²⁺] = [Cl⁻]  
B. [OH⁻] > [Ca²⁺] > [Cl⁻]  
C. [OH⁻] > [Ca²⁺] = [Cl⁻]  
D. [OH⁻] = [Ca²⁺] > [Cl⁻]

11. Hydrogen has two naturally occurring stable isotopes, whereas oxygen has three. How many types of stable water molecules are there in nature?

A. 6  
B. 9  
C. 12  
D. 15
12. For a reversible reaction \( A \rightleftharpoons B + C \), \( A \) is continuously converted to \( B \) and \( C \), and \( B \) and \( C \) are converted back to \( A \), resulting in a constant concentration ratio known as equilibrium constant \( K = \frac{[B][C]}{[A]} \). This type of reaction is said to be in a dynamic equilibrium. To a mixture of \( A \), \( B \) and \( C \) in dynamic equilibrium, more of \( B \) was added. Considering that a new equilibrium is established, which of the following is true?

A. \( A \) is decreased, while \( C \) is increased  
B. Both \( A \) and \( C \) are increased  
C. \( A \) is increased, while \( C \) is unchanged  
D. \( A \) is increased, while \( C \) is decreased

13. On a balance scale identical solutions of hydrochloric acid are placed such that the scales are exactly even. To one side, 1 g of sodium carbonate is added. A student rebalanced the scales by adding \( m \) g of potassium carbonate to the solution on the other side. Which of the following is true?

A. \( m > 1 \)  
B. \( m < 1 \)  
C. \( m = 1 \)  
D. impossible to tell


<table>
<thead>
<tr>
<th>Element</th>
<th>Atomic Radius (pm)</th>
<th>Atomic mass (g/mol)</th>
<th>Density (g/cm(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr</td>
<td>166</td>
<td>52</td>
<td>7.15</td>
</tr>
<tr>
<td>Ag</td>
<td>165</td>
<td>108</td>
<td>10.49</td>
</tr>
<tr>
<td>Pd</td>
<td>169</td>
<td>106</td>
<td>12.02</td>
</tr>
<tr>
<td>Cd</td>
<td>161</td>
<td>112</td>
<td>8.65</td>
</tr>
</tbody>
</table>

Which of the following can be deduced from the table?

A. Pd has the most no of atoms in unit volume  
B. The atoms in different elements pack differently  
C. Heavier elements always have higher density  
D. Density of an element depends on the ratio of atomic mass to radius
15. Radioactive isotopes decay in a predictable fashion, where the time that it takes for half of the material to decay is constant and is known as half-life. Technetium-99m is an unstable isotope that is commonly used as a radioactive tracer in medical imaging. Given the following concentration vs time data for the decay of Technetium-99m, what is the concentration (in mol/L) after 24 h?

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Concentration (mol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.0</td>
</tr>
<tr>
<td>1</td>
<td>1.8</td>
</tr>
<tr>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>6</td>
<td>1.0</td>
</tr>
<tr>
<td>9</td>
<td>0.71</td>
</tr>
<tr>
<td>12</td>
<td>0.50</td>
</tr>
<tr>
<td>15</td>
<td>0.35</td>
</tr>
</tbody>
</table>

A. 0  B. 0.25  C. 0.0625  D. 0.125

16. Consider the following step-wise reactions: \( \text{A} \rightarrow \text{B} \rightarrow \text{C} \), where only A is present initially. When \( \text{A} \rightarrow \text{B} \) is much faster than \( \text{B} \rightarrow \text{C} \), the following concentration vs time plots are obtained:

What will the \( \text{B} \) vs time plot look like if instead \( \text{A} \rightarrow \text{B} \) is much slower than \( \text{B} \rightarrow \text{C} \)?

A.  
B.  
C.  
D.  

---

ChemCo 2018
17. Below is a 3D space-filling model of an anti-diabetic drug chlorpropamide displayed from three different perspectives.

Which of the following structures corresponds to the structure of chlorpropamide?

A. Cl\[\text{SO}_2\text{N}-\text{NH}]-\text{CH}[-\text{CH}_2\text{NH}-\text{CH}_3]

B. Cl\[\text{O}-\text{N}\]-\text{NH}-\text{NH\text{CH}_2\text{NH}]-\text{CH}[-\text{CH}_2\text{NH}-\text{CH}_3]

C. H\text{CH}_3\[\text{SO}_2\text{N}-\text{NH}]-\text{CH}[-\text{CH}_2\text{NH}-\text{CH}_3]

D. H\text{CH}_3\[\text{O}-\text{N}\]-\text{NH}-\text{NH\text{CH}_2\text{NH}]-\text{CH}[-\text{CH}_2\text{NH}-\text{CH}_3]

18. Alkanes tend to undergo free radical substitutions. In the reaction process there are three steps, namely, initiation, propagation and termination. An example of methane reacting with chlorine gas is shown below:

Initiation: \( \text{Cl}_2 \rightarrow 2\text{Cl}^* \)

Propagation: \( \text{Cl}^* + \text{CH}_4 \rightarrow \text{HCl} + \text{CH}_3^* \)
\( \text{CH}_3^* + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}^* \)

Termination: \( \text{Cl}^* + \text{CH}_3^* \rightarrow \text{CH}_3\text{Cl} \)
\( \text{CH}_3^* + \text{CH}_3^* \rightarrow \text{CH}_3\text{CH}_3 \)

In the termination step, two radicals come together to form a stable compound. Consider the following alkane.

\[ \text{C}_5\text{H}_{12} \]

Which of the following molecules cannot be obtained in the termination step?

A. \[ \text{C}_5\text{H}_{12} \]
B. \[ \text{C}_5\text{H}_{12} \]
C. \[ \text{C}_5\text{H}_{12} \]
D. \[ \text{C}_5\text{H}_{12} \]
19. Equal volumes of ammonia and oxygen gases are mixed in a sealed container and the starting pressure is $P$. After the reaction, the gases are cooled down to initial temperature and water is fully condensed. Assuming the reaction is complete, what is the final pressure?

$$4\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{N}_2 + 6\text{H}_2\text{O}$$

A. $P$  
B. $\frac{1}{4}P$  
C. $\frac{3}{8}P$  
D. $\frac{9}{8}P$

20. When a 10.0 g of an unknown metal oxide is heated in a stream of hydrogen, the solid metal and 1.26 g of water is formed. What is the unknown metal?

A. Cu  
B. Ag  
C. Fe  
D. Zn
PART B


The four fragments must be assembled together to solve this problem. Use the following hints:

- Elements A3, B1 and C1 are in the same period.
- Elements A2 and C4 are in the same group.
- The fragment A1-4 consists of only gases at room temperature and pressure.
- The fragment B1-4 consists of only solids at room temperature and pressure.
- Element B3 is the only metal among the given elements.
- The atomic number of D is smaller than that of A4, but larger than that of B4.

a. What element in the fragment A1-4 is in the same period as C4? Tick one.

b. Which of these elements is the lightest? Tick one.

c. What is the most electronegative element? Tick one.

d. What is the actual symbol of the element D?
2. [3] Thin layer chromatography (TLC) is a common separating technique used to monitor chemical reactions. A solution is spotted at the base line of a TLC plate, and the TLC plate is placed vertically in a glass container with a solvent of choice wetting the TLC plate just below the base line. The solvent travels up the plate carrying chemical substances up to different extents, separating them. After the solvent reaches the top, the individual substances can be "visualized" under UV-light or with a suitable reagent. The extent to which a substance travels is typically unique for that substance as long as the same solvent is used.

Two reagents, R1 and R2, were reacted to form a product P, and the reaction was monitored by TLC. On the left TLC the reagents and the authentic product were run for reference. The reaction was then monitored by TLC at different time points.

Tick either True or False with regard to the following statements:

a. The product started forming by 1 h. True  False

b. The reaction was complete at 2 h. True  False

c. Reagent 1 was used in excess. True  False

d. The product can be found in the reaction mixture after 8 h. True  False
3. [3] Balance the following reactions with the lowest whole number coefficients and indicate the sum as shown in the example.

Example: \[ \_2 \text{H}_2 + \_1 \text{O}_2 = \_2 \text{H}_2\text{O} \]

a. \[ \_ \text{HBr} + \_ \text{Sr(OH)}_2 = \_ \text{SrBr}_2 + \_ \text{H}_2\text{O} \]

b. \[ \_ \text{KMnO}_4 = \_ \text{K}_2\text{MnO}_4 + \_ \text{MnO}_2 + \_ \text{O}_2 \]

c. \[ \_ \text{Sn}^{2+} + \_ \text{Ce}^{4+} = \_ \text{Sn}^{4+} + \_ \text{Ce}^{3+} \]

d. \[ \_ \text{Fe}_3\text{O}_4 + \_ \text{H}_2\text{SO}_4 = \_ \text{Fe}_2(\text{SO}_4)_3 + \_ \text{SO}_2 + \_ \text{H}_2\text{O} \]

4. [2] For each reaction tick the correct reaction type.

a. \( \text{NaHSO}_4 + \text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{O} \)

   \[ \square \text{ decomposition} \quad \square \text{ neutralization} \quad \square \text{ redox} \]

b. \( \text{Cu} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{SO}_2 + 2\text{H}_2\text{O} \)

   \[ \square \text{ decomposition} \quad \square \text{ neutralization} \quad \square \text{ redox} \]

c. \( 2\text{Fe(OH)}_3 \rightarrow \text{Fe}_2\text{O}_3 + 3\text{H}_2\text{O} \)

   \[ \square \text{ decomposition} \quad \square \text{ neutralization} \quad \square \text{ redox} \]

d. \( \text{H}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O} \)

   \[ \square \text{ decomposition} \quad \square \text{ neutralization} \quad \square \text{ redox} \]

5. [3] Element X is the most abundant element on earth. X forms two hydroxides, A and B. Heating A produces a solid residue C and a gas D, which condenses upon cooling. C dissolves in hydrochloric acid, forming a green solution, which slowly turns brown. Heating of hydroxide B gives a solid E and the gas D. E dissolves in hydrochloric acid, forming a brown solution. Indicate the identities of element X and compounds A-E.

Element X:

Compounds A: B: C: D: E:
6. [1.5] Globally harmonized system of classification and labelling of chemicals (GSH) defines and classifies the hazards of chemicals and communicates health and safety information. Hazard information associated with some chemicals are given below:

<table>
<thead>
<tr>
<th>No.</th>
<th>Chemical</th>
<th>GHS Label</th>
<th>Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sodium hydroxide</td>
<td>![Corrosive icon]</td>
<td>Causes severe skin burns and eye damage. Corrosive</td>
</tr>
<tr>
<td>2</td>
<td>Acetone</td>
<td>![Flammable icon]</td>
<td>Causes serious eye irritation. Highly flammable</td>
</tr>
<tr>
<td>3</td>
<td>Hydrogen peroxide</td>
<td>![Flammable icon]</td>
<td>May intensify fire. Oxidizer</td>
</tr>
<tr>
<td>4</td>
<td>Mercury</td>
<td>![Toxic icon]</td>
<td>Causes damage to brain. Fatal if inhaled. Toxic</td>
</tr>
</tbody>
</table>

a. Bearing in mind the hazard information of each chemical, assign the chemical numbers 1-4 to the appropriate preventive measures.

i. Keep away from heat, sparks, and open flames. Keep container tightly closed.

ii. Wash skin and eyes thoroughly after handling. Wear protective gloves and clothing. Don't use in aluminum containers.

iii. Do not breathe vapors. Use only in a well-ventilated area. Wear respiratory protection, where exposure limits are exceeded.

iv. Store away from clothing and combustible materials. Avoid mixing with combustibles.

b. Which pair of chemicals must not be stored in the same compartment at all cost? Tick one.

Sodium hydroxide – Acetone: 
Acetone – Hydrogen peroxide: 
Hydrogen peroxide – Mercury: 
Mercury – Sodium hydroxide: 
7. [2] Shown below is a typical reaction energy diagram.

![Reaction Energy Diagram]

a. The reaction is (tick one) 

- [ ] exothermic
- [ ] endothermic

b. The activation energy of the reverse reaction is represented by (tick one) 

- [ ] I
- [ ] II
- [ ] III

c. The heat generated or consumed by the reaction is represented by (tick one) 

- [ ] I
- [ ] II
- [ ] III

d. A catalyst speeds up the reaction by altering the reaction pathway, lowering the minimum energy required for a molecule to react. Which of the terms are altered in the energy diagram by the use of a catalyst? Tick one.

- [ ] I and II only
- [ ] I and III only
- [ ] I, II and III
8. [1.5] Below is a drawing of a Victorian era Chemistry laboratory.

Assign numbers 1-6 to the corresponding laboratory equipment:

- Tube: □
- Separating funnel: □
- Condenser: □
- Flask: □
- Mortar and pestle: □
- Retort stand: □
PART C


Consider a 2D universe, where a 3rd dimension does not exist and everything consists of 2D molecules.

Shown below is the structure of a molecule $\text{AB}_3$, where $\text{A}$ makes two or more bonds and $\text{B}$ makes only single bonds. The three atoms of $\text{B}$ are connected to $\text{A}$ in such a way that two atoms of $\text{B}$ are pushed away as far away as possible from each other. This results in a $120^\circ \text{B} \cdot \text{A} \cdot \text{B}$ angles.

![Diagram of AB3 molecule]

a. [0.5] Following the principles outlined above, draw the shapes of $\text{AB}_2$ and $\text{AB}_4$ and clearly indicate the bond angle.

<table>
<thead>
<tr>
<th>$\text{AB}_2$</th>
<th>$\text{AB}_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>B−A−B bond angle: _______</td>
<td>B−A−B bond angle: _______</td>
</tr>
</tbody>
</table>

In addition, the central atom $\text{A}$ may have lone pairs (two dots •) of electrons denoted as $\text{E}$. They are considered as having the same repulsion force as an actual atom of $\text{B}$, however, there is no actual physical atom in their place. For example, the molecule $\text{AB}_2\text{E}$ is bent in shape with an angle of $120^\circ$.

![Diagram of AB2E molecule]

b. [0.5] Draw the structures of $\text{AB}_3\text{E}$, clearly indicating bond angles.

<table>
<thead>
<tr>
<th>$\text{AB}_3\text{E}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>B−A−B bond angle: _______</td>
</tr>
</tbody>
</table>
c. [1] There are two possible structures for $\text{AB}_2\text{E}_2$. Draw them both, clearly indicating bond angles.

<table>
<thead>
<tr>
<th>$\text{AB}_2\text{E}_2$ (structure 1)</th>
<th>$\text{AB}_2\text{E}_2$ (structure 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B–A–B bond angle: _________</td>
<td>B–A–B bond angle: _________</td>
</tr>
</tbody>
</table>

Besides connecting to atoms of $\text{B}$, atoms of $\text{A}$ can connect to each other, forming more complex molecules. Consider that $\text{A}$ always makes three bonds (either three single bonds or one single and one double bond) and $\text{B}$ always makes a single bond.

d. [0.25] Draw the structure of $\text{A}_2\text{B}_4$.

![Structure of $\text{A}_2\text{B}_4$](image)

e. [0.75] Draw all the possible structures of $\text{A}_3\text{B}_2$ and $\text{A}_3\text{B}_3$.

<table>
<thead>
<tr>
<th>$\text{A}_3\text{B}_2$</th>
<th>$\text{A}_3\text{B}_3$</th>
</tr>
</thead>
</table>

f. [2] Considering that in this 2D universe, molecules can only rotate on the 2D plane, there are four ways of drawing the molecule $\text{A}_4\text{B}_6$. Draw the three structures of $\text{A}_4\text{B}_6$.

<table>
<thead>
<tr>
<th>Structure 1:</th>
<th>Structure 2:</th>
<th>Structure 3:</th>
<th>Structure 4:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. [5] Acid-Base Titration

Given below is the titration data obtained when 20.0 mL of an unknown solution A was titrated with an unknown solution B.

<table>
<thead>
<tr>
<th>Volume B (ml)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>2.8</td>
</tr>
<tr>
<td>1.0</td>
<td>3.8</td>
</tr>
<tr>
<td>2.0</td>
<td>4.2</td>
</tr>
<tr>
<td>3.0</td>
<td>4.4</td>
</tr>
<tr>
<td>4.0</td>
<td>4.6</td>
</tr>
<tr>
<td>5.0</td>
<td>4.8</td>
</tr>
<tr>
<td>6.0</td>
<td>4.9</td>
</tr>
<tr>
<td>7.0</td>
<td>5.1</td>
</tr>
<tr>
<td>8.0</td>
<td>5.4</td>
</tr>
<tr>
<td>9.0</td>
<td>5.7</td>
</tr>
<tr>
<td>9.5</td>
<td>6.0</td>
</tr>
<tr>
<td>9.8</td>
<td>6.4</td>
</tr>
<tr>
<td>10.0</td>
<td>8.6</td>
</tr>
<tr>
<td>10.3</td>
<td>11.9</td>
</tr>
<tr>
<td>10.5</td>
<td>12.2</td>
</tr>
<tr>
<td>11.0</td>
<td>12.5</td>
</tr>
<tr>
<td>12.0</td>
<td>12.8</td>
</tr>
<tr>
<td>13.0</td>
<td>13.0</td>
</tr>
<tr>
<td>14.0</td>
<td>13.1</td>
</tr>
<tr>
<td>15.0</td>
<td>13.2</td>
</tr>
</tbody>
</table>

a. [1] Plot the titration curve.

b. [1] After analyzing the plot, choose the correct statements below:

i. Solution A is a [ ] strong acid [ ] weak acid [ ] strong base [ ] weak base

ii. Solution B is a [ ] strong acid [ ] weak acid [ ] strong base [ ] weak base

c. [1] What is the volume of B required to reach end-point and what is the pH of solution?

i. End-point volume B: [ ] ml  
ii. pH: [ ]

d. [1] The following indicators are available. Which is most suitable for this titration (tick one)?
Phenolphthalein (colorless 8.2 – 10.0 pink)  

Methyl orange (red 3.2 – 4.4 yellow)  

Bromothymol blue (yellow 6.0 – 7.6 blue)  

e. [1] Assuming A and B are both monobasic and B has a concentration of 0.10 mol/L, calculate the concentration of A.

Concentration of A: mol/L

End of Test