January 1999

Chemistry 30

Grade 12 Diploma Examination

Alberta
EDUCATION

January 1999

Chemistry 30

Grade 12 Diploma Examination

Description

Time: 2.5 h. This examination was developed to be completed in 2.5 h; however, you may take an additional 0.5 h to complete the examination.

This is a **closed-book** examination consisting of

- 44 multiple-choice and 12 numerical-response questions, each of equal value, worth 70% of the examination
- 2 written-response questions of equal value, worth 30% of the examination

This examination contains sets of related questions

A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

When required, a grey bar will be used to indicate the end of a set.

A chemistry data booklet is provided for your reference.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Instructions

- You are expected to provide your own scientific calculator.
- Use only an HB pencil for the machine-scored answer sheet.
- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- Read each question carefully.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- When performing calculations, use the values of the constants provided in the data booklet. Do **not** use the values programmed in your calculator.
- If you wish to change an answer, erase **all** traces of your first answer.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This examination is for the subject of

A. chemistry
B. biology
C. physics
D. science

Answer Sheet

● Ⓑ Ⓒ Ⓓ

Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

Examples

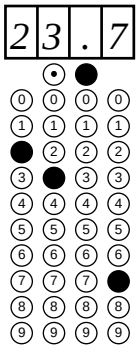
Calculation Question and Solution

The average of the values 21.0, 25.5, and 24.5 is _____.
(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Average = (21.0 + 25.5 + 24.5)/3
= 23.666

= 23.7 (rounded to three digits)

Record 23.7 on the answer sheet →



Correct-Order Question and Solution

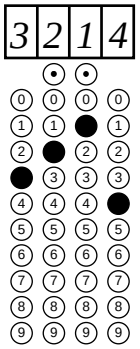
When the following subjects are arranged in alphabetical order, the order is _____.

1 physics
2 chemistry
3 biology
4 science

(Record **all four digits** of your answer in the numerical-response section on the answer sheet.)

Answer 3214

Record 3214 on the answer sheet →



Written Response

- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers must address **all** aspects of the question.
- Descriptions and/or explanations of concepts must be correct and include pertinent ideas, diagrams, calculations, and formulas.
- Your answers must be presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and made explicit.

1. Which of the following changes would release the largest amount of energy per mole?

A. $H_2O_{(g)} \rightarrow H_2O_{(s)}$

B. $^{222}_{86}Rn \rightarrow {}^{218}_{84}Po + {}^{4}_{2}He$

C. $C_{12}H_{22}O_{11(s)} + 12\,O_{2(g)} \rightarrow 12\,CO_{2(g)} + 11\,H_2O_{(g)}$

D. $C_2H_{2(g)} + \frac{5}{2}O_{2(g)} \rightarrow 2\,CO_{2(g)} + H_2O_{(g)}$

Use the following information to answer the next question.

$$Al_4C_{3(s)} + 12\,H_2O_{(l)} \rightarrow 4\,A1(OH)_{3(s)} + 3\,CH_{4(g)} \qquad \Delta H = -1763.0\ kJ$$

2. If this equation is rewritten to show the production of one mole of $CH_{4(g)}$ and the energy is expressed as a term in the equation, then the energy will be

A. 587.7 kJ on the reactant side

B. 1763.0 kJ on the reactant side

C. 587.7 kJ on the product side

D. 1763.0 kJ on the product side

Numerical Response

1. The molar enthalpy for the vaporization of water is _____ kJ/mol.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Cold packs are used to treat sprains and bruises. A chemical commonly used in cold packs is ammonium nitrate, $NH_4NO_{3(s)}$, which can produce a cooling effect.

3. The change that occurs in this cold pack is an

A. endothermic change, which results in an increase in temperature
B. exothermic change, which results in an increase in temperature
C. endothermic change, which results in a decrease in temperature
D. exothermic change, which results in a decrease in temperature

Use the following information to answer the next two questions.

A student designed a calorimetry experiment to determine the energy change for the dissolving of ammonium nitrate and recorded the following results:

heat capacity of calorimeter and water	228 J/°C
initial temperature of water	21.6°C
final temperature of water	16.4°C
mass of ammonium nitrate	0.250 g

Numerical Response

2. The amount of energy involved in this change is _____ kJ.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

4. The calculated energy change represents the enthalpy of

A. solution
B. combustion
C. neutralization
D. formation

5. When a 25.0 g sample of a metal is heated from 20.0 °C to 50.0 °C, 178 J of energy is absorbed from the surroundings. The specific heat capacity of the metal is

A. 7.12 J/g•°C

B. 0.356 J/g•°C

C. 0.237 J/g•°C

D. 0.142 J/g•°C

Use the following information to answer the next question.

Many Alberta industries burn methane to provide the energy they require. The combustion of methane can be represented by the equation

$$CH_{4(g)} + 2\,O_{2(g)} \rightarrow CO_{2(g)} + 2\,H_2O_{(g)}$$

6. As combustion proceeds, there is a significant decrease in the molecules'

A. translational motion

B. rotational motion

C. vibrational motion

D. potential energy

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7. "The use of fossil fuels as an industrial energy source contributes to global warming." The perspective of this statement is

A. scientific

B. political

C. economic

D. ecological

Use the following key to answer the next question.

Types of Bonds

1 Intermolecular
2 Intramolecular
3 Intranuclear

Numerical Response

3. Identify the type of bond, as numbered above, that is primarily involved in each change listed below.

Dry ice sublimes _____ (Record in the **first** column)

Hydrogen atoms fusing into helium _____ (Record in the **second** column)

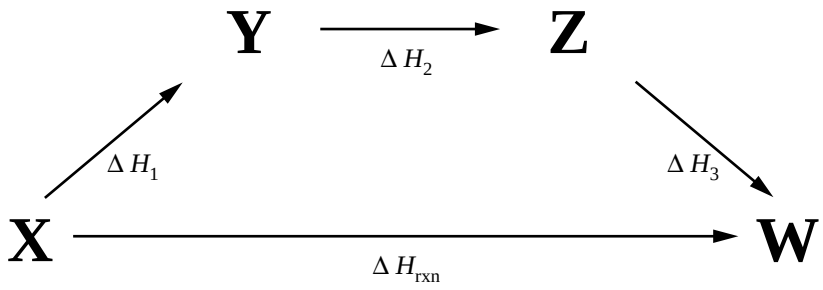
Gasoline burning in an automobile engine _____ (Record in the **third** column)

Water vapour condensing _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

The reaction $X \rightarrow W$ can proceed directly or through a series of steps, as shown.



8. This diagram illustrates

A. the Law of Conservation of Mass
B. an exothermic reaction
C. an endothermic reaction
D. Hess's Law

Bricks are produced by mixing clay and water. This mixture is then shaped into "green bricks". The green bricks are carefully heated in a kiln to transform the clay into brick. The bricks then undergo a controlled cooling before being packaged. One of the intermediate reactions in the transformation of clay into brick is

$$3\,Al_4O_6 \bullet Si_3O_{6(s)} \rightarrow (Al_2O_3)_6(SiO_2)_{4(s)} + 5\,SiO_{2(s)} + 190.4\ kJ$$

9. In the kiln, this reaction would

A. produce energy, reducing the amount of fuel required
B. produce energy, increasing the amount of fuel required
C. absorb energy, increasing the amount of fuel required
D. absorb energy, reducing the amount of fuel required

10. This reaction can be classified as

A. a redox reaction
B. a Brønsted–Lowry acid–base reaction
C. a redox reaction and a Brønsted–Lowry acid–base reaction
D. neither a redox reaction nor a Brønsted–Lowry acid–base reaction

Use the following information to answer the next question.

The colour of brick depends upon the type of clay and additives used. The reaction that occurs when clays containing iron(II) persulphide, $FeS_{2(s)}$, are heated in the kiln is

$$4\,FeS_{2(s)} + 11\,O_{2(g)} \rightarrow 2\,Fe_2O_{3(s)} + 8\,SO_{2(g)}$$

11. In this reaction, the oxidation state of iron

A. changes from 0 to +3
B. changes from +2 to +3
C. changes from +2 to 0
D. does not change

Use the following information to answer the next question.

The following reaction will occur at high temperatures.

$$2Na_{(g)} + Cl_{2(g)} \rightarrow 2NaCl_{(g)} + \text{energy}$$

12. The half-reaction for the reduction that occurs in this reaction is

A. $Na_{(g)} \rightarrow Na^{+}_{(g)} + e^{-}$

B. $Na_{(g)} + e^{-} \rightarrow Na^{+}_{(g)}$

C. $Cl_{2(g)} + 2e^{-} \rightarrow 2Cl^{-}_{(g)}$

D. $Cl_{2(g)} \rightarrow 2Cl^{-}_{(g)} + 2e^{-}$

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13. Four metals represented by the symbols R, S, T, and V and their ions combine with each other in the following manner:

$$S^{2+}_{(aq)} + 2T_{(s)} \rightarrow 2T^{+}_{(aq)} + S_{(s)}$$
$$R^{3+}_{(aq)} + T_{(s)} \rightarrow \text{No Reaction}$$
$$2R^{3+}_{(aq)} + 3V_{(s)} \rightarrow 3V^{2+}_{(aq)} + 2R_{(s)}$$

When the oxidizing agents are arranged from strongest to weakest, the order is

A. $S^{2+}_{(aq)}$, $T^{+}_{(aq)}$, $R^{3+}_{(aq)}$, $V^{2+}_{(aq)}$

B. $V^{2+}_{(aq)}$, $R^{3+}_{(aq)}$, $T^{+}_{(aq)}$, $S^{2+}_{(aq)}$

C. $V_{(s)}$, $R_{(s)}$, $T_{(s)}$, $S_{(s)}$

D. $S_{(s)}$, $T_{(s)}$, $R_{(s)}$, $V_{(s)}$

14. In the reaction of sodium metal with water, the reduction half-reaction produces

A. hydroxide ions, which results in a pH greater than 7

B. hydroxide ions, which results in a pH less than 7

C. hydrogen gas, which results in a pH less than 7

D. hydrogen gas, which results in a pH of 7

Restorers of antique cars often refinish chrome-plated parts by electroplating them. The part is attached to one electrode of an electrolytic cell in which the other electrode is lead. The electrolyte is a solution of dichromic acid, $H_2Cr_2O_{7(aq)}$.

15. The plating of chromium metal will take place at the

A. anode where oxidation occurs
B. anode where reduction occurs
C. cathode where oxidation occurs
D. cathode where reduction occurs

16. During the operation of this cell,

A. $Pb_{(s)}$ is reduced
B. $H_2Cr_2O_{7(aq)}$ is oxidized
C. the pH of the solution increases
D. the total energy of the system decreases

17. A metal that will react spontaneously with $Cr^{3+}_{(aq)}$ in a chromium-plating solution is

A. aluminum
B. cadmium
C. lead
D. tin

Use the following information to answer the next question.

When chromium is electroplated onto a car bumper, one of the chemicals put into the electrolytic solution is $CrO_{3(s)}$. This chemical reacts with water as represented by the equation

$$2CrO_{3(s)} + H_2O_{(l)} \rightarrow 2H^+_{(aq)} + Cr_2O_7^{2-}{}_{(aq)}$$

18. A correct statement concerning this reaction is that

A. the chromium undergoes oxidation

B. the resulting solution will have a pH > 7

C. this is a Brønsted–Lowry acid–base reaction

D. the oxidation state of chromium does not change

19. If the electrochemical cell $Cd_{(s)} / Cd^{2+}_{(aq)} // Ag^{+}_{(aq)} / Ag_{(s)}$ produces a 6.00 A current for 2.00 h, the mass change of the anode will be a

A. 25.2 g decrease

B. 2.25 g increase

C. 48.3 g decrease

D. 48.3 g increase

20. "Tin" cans used to store food are made from steel electroplated with a thin layer of tin. The standard electrical potential for the reduction of $Sn^{2+}_{(aq)}$ ions for this process is

A. –0.15 V

B. –0.14 V

C. +0.14 V

D. +0.15 V

21. In an experiment, a student compares several electrochemical cells. Each cell contains two metal strips in their metallic ion solutions. A voltmeter is connected by a wire between the metal strips, and a salt bridge connects the solutions. The dependent (responding) variable is the

A. voltage

B. concentration of the solution

C. reaction of a metal and a metallic ion

D. metal and metallic ion solution selected

Use the following information to answer the next three questions.

A student dipped 12.50 g strips of four different metals, $Ag_{(s)}$, $Cu_{(s)}$, $Pb_{(s)}$, and $Mg_{(s)}$, into a beaker containing 250 mL of 1.00 mol/L $HCl_{(aq)}$ in order to determine an activity series. One of the metals reacted immediately and vigorously with the acid.

22. The balanced net-ionic equation for the first reaction that occurred is

A. $2Ag_{(s)} + 2H^{+}_{(aq)} \rightarrow H_{2(g)} + 2Ag^{+}_{(aq)}$

B. $Cu_{(s)} + 2H^{+}_{(aq)} \rightarrow H_{2(g)} + Cu^{2+}_{(aq)}$

C. $Pb_{(s)} + 2H^{+}_{(aq)} \rightarrow H_{2(g)} + Pb^{2+}_{(aq)}$

D. $Mg_{(s)} + 2H^{+}_{(aq)} \rightarrow H_{2(g)} + Mg^{2+}_{(aq)}$

*Use the answer selected for **Multiple Choice 22** to answer **Numerical Response 4.****

Numerical Response

4. The electrical potential for this reaction is +/– _____ V.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

*Use the answer selected for **Multiple Choice 22** to answer **Numerical Response 5.****

Numerical Response

5. The mass of metal that reacted with the hydrochloric acid is _____ g.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if Multiple Choice 22 was answered incorrectly.**

Use the following information to answer the next question.

During the operation of a NiCad battery, the two half-reactions that occur are

I $Cd_{(s)} + 2OH^-_{(aq)} \rightarrow Cd(OH)_{2(s)} + 2e^-$ $E° = ?$ V

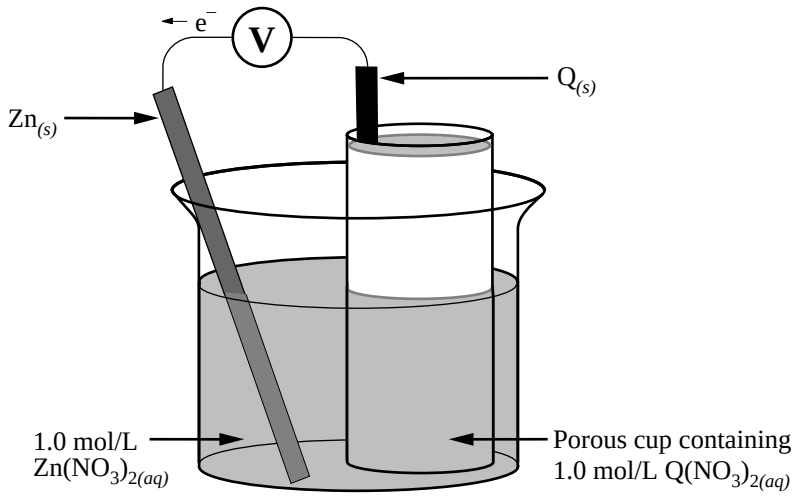
II $NiO_{2(s)} + 2H_2O_{(l)} + 2e^- \rightarrow Ni(OH)_{2(s)} + 2OH^-_{(aq)}$ $E° = -0.49$ V

Numerical Response

6. On discharging, the electrical potential of a NiCad battery is +1.40 V.
The reduction potential for half-reaction I is $-$_____ V.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Use the following diagram to answer the next question.



23. Given that the reading on the voltmeter for this cell is +1.74 V, which of the following statements is correct?

A. The reduction potential of $Q^{2+}_{(aq)}$ is +2.50 V.

B. $Zn_{(s)}$ is a weaker reducing agent than $Q_{(s)}$.

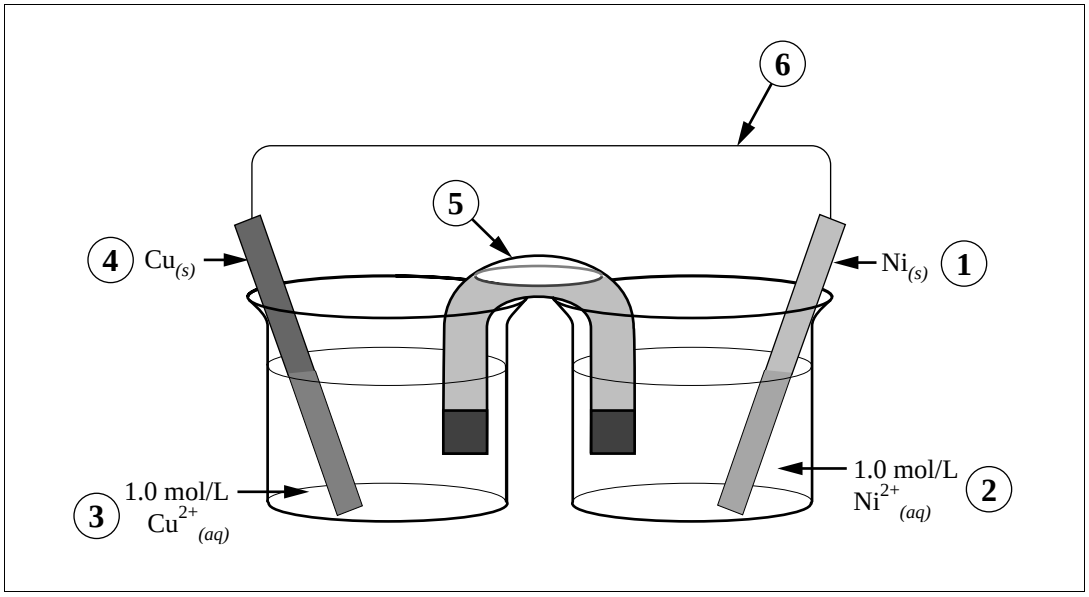
C. $Q^{2+}_{(aq)}$ would react spontaneously with $Cu_{(s)}$.

D. $Q^{2+}_{(aq)}$ is a stronger oxidizing agent than $Zn^{2+}_{(aq)}$.

24. An electrolytic cell differs from a voltaic cell in that the electrolytic cell

A. is spontaneous
B. consumes electricity
C. has an anode and a cathode
D. has a positive $E°_{net}$ value

Use the following diagram to answer the next question.



Numerical Response

7. Identify the part of the electrochemical cell, as numbered above, that corresponds to the terms listed below.

Cathode _____ (Record in the **first** column)
External electron circuit _____ (Record in the **second** column)
Oxidizing agent _____ (Record in the **third** column)
Anode _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

25. Oxidation–reduction reactions occur in biological systems. A net oxidation–reduction reaction that occurs in the body is

A. $Mg^{2+}_{(aq)} + 2\,OH^{-}_{(aq)} \rightarrow Mg(OH)_{2(s)}$

B. $HCO_3^{-}{}_{(aq)} + H_3O^{+}_{(aq)} \rightarrow H_2CO_{3(aq)} + H_2O_{(l)}$

C. $CH_{4(g)} + 2\,O_{2(g)} \rightarrow CO_{2(g)} + 2\,H_2O_{(g)}$

D. $C_6H_{12}O_{6(aq)} + 6\,O_{2(g)} \rightarrow 6\,CO_{2(g)} + 6\,H_2O_{(l)}$

26. Blood maintains a nearly constant pH because it contains

A. sodium ions and chloride ions that keep the pH of the blood at 7

B. hemoglobin that maintains the oxygen levels in the blood

C. catalysts (enzymes) that control the equilibrium in the blood

D. buffers that regulate the hydronium ion concentration in the blood

27. In $HCO_3^{-}{}_{(aq)}$, carbon has an oxidation state of

A. +4

B. +1

C. 0

D. –4

28. An ionic solid dissolves and produces an equilibrium system. Which of the following statements about this system is **incorrect**?

A. The temperature of the solution is constant.

B. No solid is present at the bottom of the container.

C. Vigorous stirring does not dissolve more of the solid.

D. If the solution is heated, the amount of the solid that dissolves changes.

Sodium azide, which is found in automobile air bags, reacts readily with acids to form the highly toxic and explosive hydroazoic acid $HN_{3(aq)}$. The K_a for hydroazoic acid is 1.9×10^{-5}.

29. The K_a expression for hydroazoic acid is

A. $K_a = \dfrac{[HN_{3(aq)}]}{[H_3O^+_{(aq)}]\,[N_3^-(aq)]}$

B. $K_a = \dfrac{[H_3O^+_{(aq)}]\,[N_3^-(aq)]}{[HN_{3(aq)}]}$

C. $K_a = \dfrac{[HN_{3(aq)}]^3}{[H_3O^+_{(aq)}]\,[N_3^-(aq)]^3}$

D. $K_a = \dfrac{[H_3O^+_{(aq)}]\,[N_3^-(aq)]^3}{[HN_{3(aq)}]^3}$

30. In a solution of hydroazoic acid, the

A. $[HN_{3(aq)}] < [N_3^-{}_{(aq)}]$

B. $[HN_{3(aq)}] > [H_3O^+_{(aq)}]$

C. $[HN_{3(aq)}] > [H_2O_{(l)}]$

D. $[HN_{3(aq)}] = [H_3O^+_{(aq)}]$

Numerical Response

8. The pH of a 0.28 mol/L $HN_{3(aq)}$ solution is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Numerical Response

9. The volume of 6.00 mol/L $NaOH_{(aq)}$ required to neutralize 2.20 kg of $HN_{3(l)}$ is _____ L.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

31. A solution was tested and found to have a pOH of 3.2. This solution would most likely

A. be a proton donor

B. react violently with zinc

C. cause thymolphthalein to be blue

D. cause bromocresol green to be yellow

Numerical Response

10. At a temperature of 300°C and a pressure of 40.5 MPa, 90.0 mol of $H_{2(g)}$ and 80.0 mol of $N_{2(g)}$ are injected into a reaction vessel. When equilibrium is established, 37.0 mol of $NH_{3(g)}$ are present. The number of moles of $H_{2(g)}$ present in this equilibrium mixture is _____ mol.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

Hydrogen fluoride is produced by reacting hydrogen with fluorine.

$$H_{2(g)} + F_{2(g)} \rightleftharpoons 2HF_{(g)} \qquad \Delta H = -542.2 \text{ kJ}$$

32. A stress that would shift the equilibrium toward the products would be to

A. remove $H_{2(g)}$
B. add $HF_{(g)}$
C. decrease the volume of the reaction vessel
D. decrease the temperature of the reaction vessel

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33. The K_b of $F^-_{(aq)}$ is

A. 6.6×10^{-4}
B. 1.5×10^{17}
C. 1.5×10^{-11}
D. 1.0×10^{-14}

34. Which of the following dilute solutions would likely have a sour taste?

A. $NH_{3(aq)}$
B. $NaOH_{(aq)}$
C. $NaHCO_{3(aq)}$
D. $CH_3COOH_{(aq)}$

35. The $[OH^-_{(aq)}]$ of a solution with a pH = 3.45 is

A. 1.9×10^{-14} mol/L
B. 2.8×10^{-11} mol/L
C. 3.6×10^{-4} mol/L
D. 0.54 mol/L

36. In which of the following reactions does equilibrium favour the products?

A. $HSO_4^{-}{}_{(aq)} + F^{-}{}_{(aq)} \rightleftharpoons HF_{(aq)} + SO_4^{2-}{}_{(aq)}$

B. $HF_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^{+}{}_{(aq)} + F^{-}{}_{(aq)}$

C. $HF_{(aq)} + SO_4^{2-}{}_{(aq)} \rightleftharpoons HSO_4^{-}{}_{(aq)} + F^{-}{}_{(aq)}$

D. $H_3BO_{3(aq)} + F^{-}{}_{(aq)} \rightleftharpoons HF_{(aq)} + H_2BO_3^{-}{}_{(aq)}$

Use the following information to answer the next question.

Two cleaning solutions were accidentally mixed. A strong smell of ammonia alerted a technician to the accident. After checking the labels of the cleaners and discovering that one container held $NH_4Cl_{(aq)}$ and the other $KOH_{(aq)}$, the technician determined that the smell came from the following reaction:

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

37. In this equilibrium, the Brønsted–Lowry acids are

A. $NH_{3(aq)}$ and $H_2O_{(l)}$

B. $NH_4^{+}{}_{(aq)}$ and $H_2O_{(l)}$

C. $NH_{3(aq)}$ and $OH^{-}{}_{(aq)}$

D. $NH_4^{+}{}_{(aq)}$ and $OH^{-}{}_{(aq)}$

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38. The conjugate base of $N_2H_5^{+}{}_{(aq)}$ is

A. $HOH_{(l)}$

B. $OH^{-}{}_{(aq)}$

C. $N_2H_{4(aq)}$

D. $N_2H_6^{2+}{}_{(aq)}$

39. As a 1.0 mol/L $HCl_{(aq)}$ solution is added continuously to a 1.0 mol/L $NaOH_{(aq)}$ solution containing thymol blue indicator, the colour changes from

A. blue to green to yellow to orange to red

B. red to orange to yellow to green to blue

C. yellow to orange to red

D. yellow to green to blue

40. Which of the following species could act as either an acid or a base?

A. $H_2SeO_{4(aq)}$

B. $AsO_4^{3-}{}_{(aq)}$

C. $HCOO^-{}_{(aq)}$

D. $H_2BO_3^-{}_{(aq)}$

41. A reaction favouring reactants in which $HCO_3^-{}_{(aq)}$ acts as an acid is

A. $HCO_3^-{}_{(aq)} + HBO_3^{2-}{}_{(aq)} \rightleftharpoons H_2BO_3^-{}_{(aq)} + CO_3^{2-}{}_{(aq)}$

B. $HCO_3^-{}_{(aq)} + HPO_4^{2-}{}_{(aq)} \rightleftharpoons H_2PO_4^-{}_{(aq)} + CO_3^{2-}{}_{(aq)}$

C. $HCO_3^-{}_{(aq)} + CH_3COOH_{(aq)} \rightleftharpoons H_2CO_{3(aq)} + CH_3COO^-{}_{(aq)}$

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

42. When $Na_2CO_{3(s)}$ is added to an unknown solution, bubbles are produced. The unknown solution would be expected to

A. feel slippery

B. have a high pH

C. turn litmus red

D. turn thymolphthalein blue

Use the following information to answer the next two questions.

A student titrated a 10.0 mL sample of nitric acid with sodium hydroxide solution in the presence of an indicator.

Volume of 5.00 mmol/L $NaOH_{(aq)}$ Used

Trial	**1**	**2**	**3**	**4**
Final Buret Reading (mL)	7.99	14.51	21.02	27.53
Initial Buret Reading (mL)	1.00	7.99	14.51	21.02

Numerical Response

11. The average volume of titrant used is _____ mL.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

*Use your **recorded value** from **Numerical Response 11** to answer **Numerical Response 12.****

Numerical Response

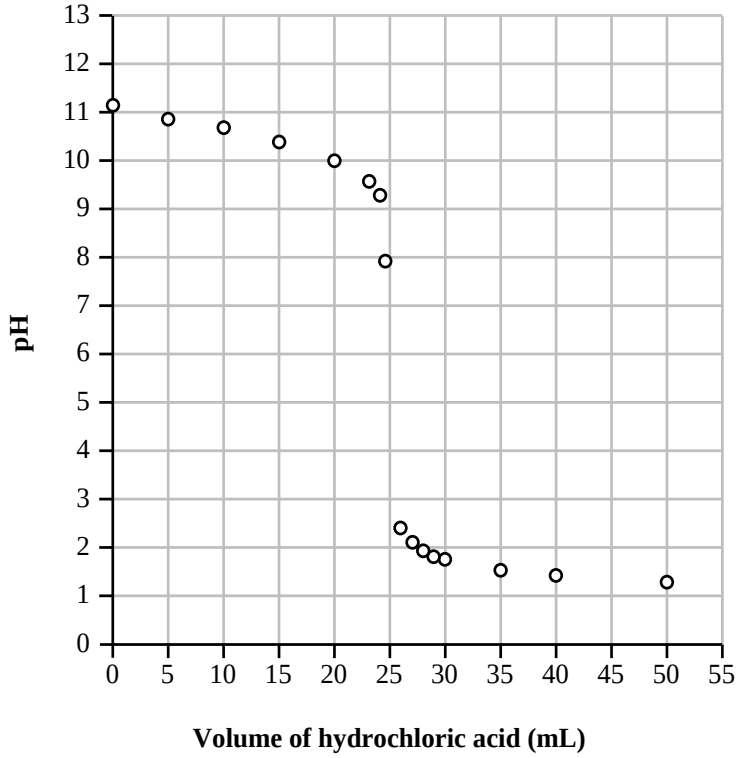
12. The concentration of the nitric acid is _____ mmol/L.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

Use the following information to answer the next question.

Titration Plot for 25.0 mL of 0.100 mol/L $NH_{3(aq)}$ with 0.100 mol/L $HCl_{(aq)}$



43. The most suitable indicator for the titration is

A. phenolphthalein
B. methyl violet
C. chlorophenol red
D. methyl orange

44. Which of the following equimolar solutions could act as a buffer system?

A. $KH_2PO_{4(aq)}$ / $H_3PO_{4(aq)}$

B. $KCl_{(aq)}$ / $HCl_{(aq)}$

C. $KClO_{4(aq)}$ / $HClO_{4(aq)}$

D. $KNO_{3(aq)}$ / $HNO_{3(aq)}$

The written-response questions follow on the next page.

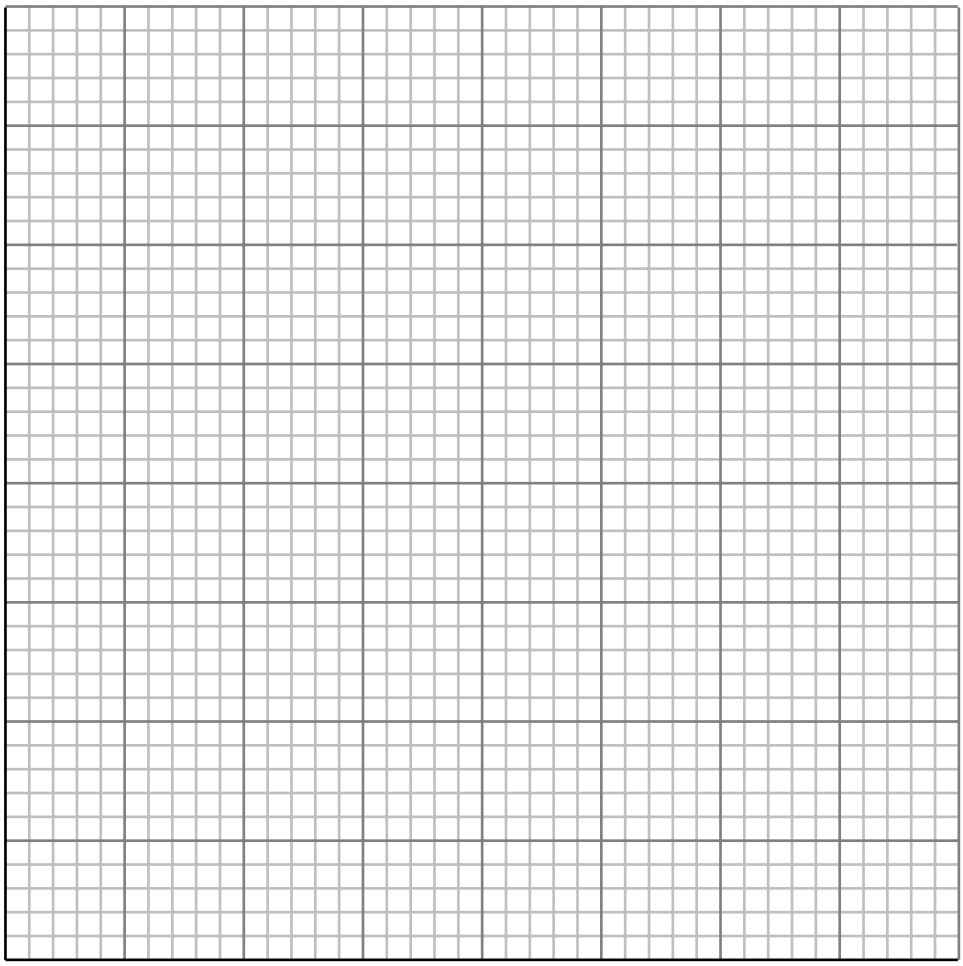
Written Response—15%

1. The combustion of sugar in a bomb calorimeter is similar to the oxidation of sugar in the body. A student ate three sugar cubes, with masses of 6.84 g, 6.75 g, and 6.79 g.

a. Calculate the overall molar enthalpy of oxidation of sugar, $C_{12}H_{22}O_{11(s)}$, in the body.

b. Using these three sugar cubes as representative of regular-sized cubes, determine the amount of energy released by an average-sized cube.

c. Draw and label a potential energy diagram representing the molar enthalpy of oxidation of sugar in the body.



Written Response—15%

2. An unidentified acid with a concentration of 1.0 mol/L has been given to you to identify. The acid appears in your data booklet on the Relative Strengths of Acids and Bases table. The following test results were recorded:

1. Methyl violet is yellow when added to the acid.

2. The acid did not form a precipitate when a solution containing $Ag^{+}_{(aq)}$ was added to it.

3. The solution turned blue and a gas was formed when a strip of copper was added to the acid.

Based on these test results, identify the acid and justify your choice. Your answer should include equations and/or calculations where appropriate.

You have now completed the examination.
If you have time, you may wish to check your answers.

CHEMISTRY 30

Multiple-Choice

1.	B	**23.**	B
2.	C	**24.**	B
3.	C	**25.**	D
4.	A	**26.**	D
5.	C	**27.**	A
6.	D	**28.**	B
7.	D	**29.**	B
8.	D	**30.**	B
9.	A	**31.**	C
10.	D	**32.**	D
11.	B	**33.**	C
12.	C	**34.**	D
13.	A	**35.**	B
14.	A	**36.**	A
15.	D	**37.**	B
16.	C	**38.**	C
17.	A	**39.**	A
18.	D	**40.**	D
19.	A	**41.**	B **or A for French Translation**
20.	B	**42.**	C
21.	A	**43.**	C
22.	D	**44.**	A

Numerical-Response

1.	40.8 or 44.0	**7.**	4631
2.	1.19	**8.**	2.64
3.	1321	**9.**	8.52
4.	2.37*	**10.**	34.5
5.	3.04*	**11.**	6.51 or 6.63
6.	1.89	**12.**	3.26*

Linked-Item* Responses

*If MC 22 is A, then NR4 is 0.80
B, then NR4 is 0.34
C, then NR4 is 0.13
D, then NR4 is 2.37

*If MC 22 is A, then NR5 is 12.5
B, then NR5 is 7.94
C, then NR5 is 12.5
D, then NR5 is 3.04

*NR12 = (NR11)/2
= 3.26

SAMPLE ANSWER KEY FOR WRITTEN-RESPONSE QUESTION

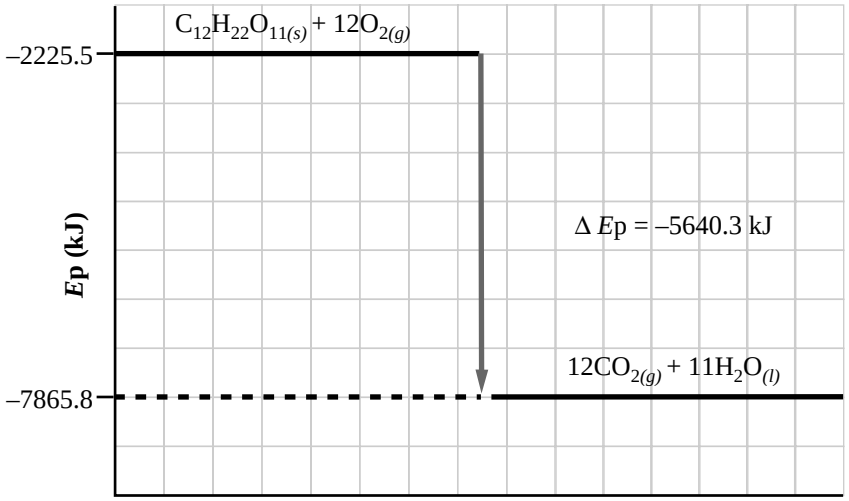
1. a. $C_{12}H_{22}O_{11(s)} + 12\,O_{2(g)} \rightarrow 12\,CO_{2(g)} + 11\,H_2O_{(l)}$

$$\Delta E_p = 12(-393.5\text{ kJ}) + 11(-285.8\text{ kJ}) - (-2225.5\text{ kJ})$$
$$= -5640.3\text{ kJ}$$

The molar enthalpy for the oxidation of sucrose is –5640.3 kJ/mol.

b. $\left(\frac{6.84+6.75+6.79}{3}\right)\text{g}\left(\frac{1\text{ mol}}{342.34\text{ g}}\right)5\,640.3\text{ kJ/mol} = 112\text{ kJ}$

c. ***E*p diagram for $C_{12}H_{22}O_{11(s)}$**



2. The pH of the sample is zero or less since methyl violet is yellow at pHs of zero or less. Hence the only acids with pHs of zero or less, with a concentration of 1.0 mol/L are $HClO_{4(aq)}$, $HI_{(aq)}$, $HBr_{(aq)}$, $HCl_{(aq)}$, $H_2SO_{4(aq)}$, and $HNO_{3(aq)}$. (–log 1.0 = 0.00 = pH)

Silver ions cause precipitate to form in all the strong acids with exception of $HNO_{3(aq)}$ and $HClO_{4(aq)}$.

Of these acids, only two are strong enough oxidizing agents to react spontaneously with copper metal. These are $HClO_{4(aq)}$ and $HNO_{3(aq)}$.

$$ClO_4^-{}_{(aq)} + 8\,H^+{}_{(aq)} + 8\,e^- \rightarrow Cl^-{}_{(aq)} + 4\,H_2O_{(l)}$$
$$Cu_{(s)} \rightarrow Cu^{2+}{}_{(aq)} + 2\,e^-$$

$$4\,Cu_{(s)} + ClO_4^-{}_{(aq)} + 8\,H^+{}_{(aq)} \rightarrow Cl^-{}_{(aq)} + 4\,H_2O_{(l)} + 4\,Cu^{2+}{}_{(aq)}$$

SAMPLE ANSWER KEY FOR WRITTEN-RESPONSE QUESTION

$$NO_3^-{}_{(aq)} + 2\,H^+{}_{(aq)} + e^- \rightarrow NO_{2(g)} + H_2O_{(l)}$$
$$Cu_{(s)} \rightarrow Cu^{2+}{}_{(aq)} + 2\,e^-$$

$$2\,NO_3^-{}_{(aq)} + 4H^+{}_{(aq)} + Cu_{(s)} \rightarrow Cu^{2+}{}_{(aq)} + 2\,NO_{2(g)} + 2\,H_2O_{(l)}$$

Thus, the acid most likely is $HNO_{3(aq)}$ since it is the only acid that reacts with $Cu_{(s)}$ to produce a gas ($NO_{2(g)}$) and blue solution ($Cu^{2+}{}_{(aq)}$).

General Scoring Guides for Open-Response Question

CONTENT

Score	Criteria
4	The response addresses **all** key components of the question and is fully and correctly supported.
3	The response addresses **all** key components of the question. There are more correct support arguments/procedures/algorithms than incorrect or not covered.
2	The response addresses **all** key components of the question. However, there are more incorrect or unstated support arguments/procedures/algorithms than correct. **Not all** key components are presented. Therefore, the response presented is valid but incomplete. Of all possible support arguments/procedures/algorithms, more are correct than incorrect or unstated.
1	The response presented is valid but incomplete and therefore cannot generate a complete response. Of all the possible arguments/procedures/algorithms presented, more are incorrect or unstated than are correct.
0	Overall, the response presented is inappropriate or incorrect for the problem.
NR	No response given.