January 1998

Chemistry 30

Grade 12 Diploma Examination

Alberta
EDUCATION

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Chemistry 30

Grade 12 Diploma Examination

Description

Time: 2.5 h. 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, of equal value, worth 70% of the examination
- 2 written-response questions, each worth 15% 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 is used to indicate the end of a set.

A chemistry data booklet is provided for your reference.

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

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Use only an HB pencil for the machine-scored answer sheet.
- If you wish to change an answer, erase **all** traces of your first answer.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Read each question carefully.
- 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.**

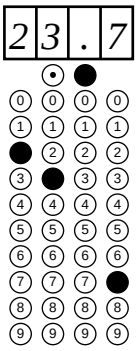
Examples

Calculation Question and Solution

The average of the values 21.0, 25.5, and 24.5 is _____.
(Record your answer to three digits 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 →



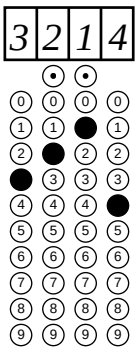
Correct-order Question and Solution

When the following subjects are arranged in alphabetical order, the order is _____. (Record all four digits on the answer sheet.)

1 physics
2 chemistry
3 biology
4 science

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 be well organized and address **all** the main points of the question.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and made explicit.
- Description and/or explanations of concepts must be correct and reflect pertinent ideas, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.

One winter evening, Pat decided to make ice cubes by placing a water-filled ice-cube tray outside. The ice-cube tray initially contained 112.6 g of water at 17.2°C. The next morning, the water in the tray had frozen completely and the outside temperature was 0.0°C.

1. In order to freeze, the water had to undergo

A. a decrease in kinetic energy and then an increase in potential energy
B. a decrease in potential energy and then a decrease in kinetic energy
C. a decrease in kinetic energy and then a decrease in potential energy
D. an increase in potential energy and then an increase in kinetic energy

2. The change in the potential energy of the water was

A. 679 kJ
B. 37.7 kJ
C. 22.5 kJ
D. 6.03 kJ

Numerical Response

1. The change in the kinetic energy of the water was_____ kJ.

(Record your answer to three digits on the answer sheet.)

Numerical Response

2. The total energy involved in the cooling and freezing of the water was _____ kJ.

(Record your answer to three digits on the answer sheet.)

3. Uranium-235, when bombarded with neutrons, may undergo nuclear fission according to the equation

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow \text{“element X”} + {}^{94}_{40}\text{Zr} + 3\,{}^{1}_{0}\text{n}.$$

“Element X” is

A. $^{139}_{52}\text{Te}$

B. $^{137}_{53}\text{I}$

C. $^{139}_{53}\text{I}$

D. $^{136}_{54}\text{Xe}$

Use the following information to answer the next question.

1 sublimation	**3** melting
2 nuclear fission	**4** combustion

Numerical Response

3. Assuming that each of the above processes involves the same element, the processes listed in order of increasing magnitude of energy are _____ .

(Record all four digits of your answer on the answer sheet.)

The Sun is the original source of energy stored in fossil fuels. Energy transformations affect the quality of life on the planet. Burning fossil fuels increases levels of atmospheric carbon dioxide, which may contribute to the greenhouse effect.

4. The molar heat of combustion for propane, assuming gaseous products are formed, is

A. –2251.5 kJ/mol

B. –2219.9 kJ/mol

C. –2043.9 kJ/mol

D. –103.8 kJ/mol

5. The combustion of hydrogen gas as an automobile fuel is an attractive alternative to the combustion of fossil fuels because

A. the fuel tank for hydrogen gas would be smaller

B. burning hydrogen gas forms non-polluting products

C. hydrogen gas is less expensive and is readily available for use

D. the molar heat of combustion for hydrogen gas is greater than those of the hydrocarbon fuels

6. Which of the following substances contained in automobile exhaust is also produced in cellular respiration?

A. H_2O

B. SO_2

C. Unburned hydrocarbons

D. Nitrogen oxide compounds

Use the following information to answer the next three questions.

Fuel	Molar Enthalpy of Combustion
methane	–802.3 kJ/mol
butane	–2656.5 kJ/mol
octane	–5074.2 kJ/mol
ethyne	–1255.5 kJ/mol

7. An interpretation from the table is that, the greater the number of covalent bonds in a fossil fuel molecule, the

A. lower the energy stored in the molecule

B. greater the energy released on combustion

C. lower the moles of oxygen required for complete combustion

D. greater the strength of each covalent bond

8. Which of the following fuels produces the greatest amount of heat per mole of carbon dioxide produced?

A. Methane

B. Butane

C. Octane

D. Ethyne

Use this additional information to answer the next question.

$$CH_3OH_{(l)} + \tfrac{3}{2}O_{2(g)} \rightarrow CO_{2(g)} + 2\,H_2O_{(g)} \qquad \Delta H = -638.1 \text{ kJ}$$

9. One possible explanation for the fact that less energy is released in the combustion of methanol than in the combustion of methane is that methane has

A. less potential energy than methanol

B. more potential energy than methanol

C. more kinetic energy than methanol

D. less kinetic energy than methanol

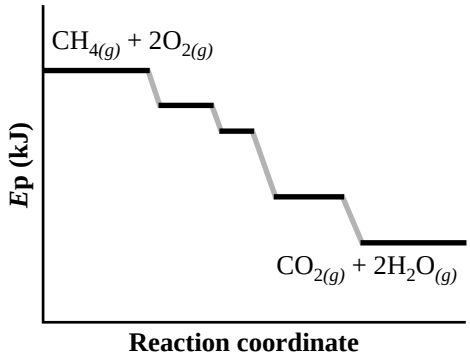
Use the following information to answer the next question.

Scientists have proposed that the burning of methane involves the following four-step reaction pathway.

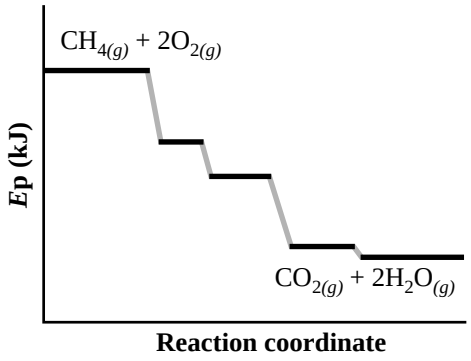
Step 1	$CH_{4(g)} + \frac{1}{2}O_{2(g)} \rightarrow CH_3OH_{(l)}$	$\Delta H = -164.2$ kJ
Step 2	$CH_3OH_{(l)} + \frac{1}{2}O_{2(g)} \rightarrow CH_2O_{(g)} + H_2O_{(g)}$	$\Delta H = -118.7$ kJ
Step 3	$CH_2O_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow HCOOH_{(g)}$	$\Delta H = -308.8$ kJ
Step 4	$HCOOH_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$	$\Delta H = -210.6$ kJ

10. Assuming that all the graphs are drawn to the same scale, the graph that best represents the reaction pathway for the burning of methane is

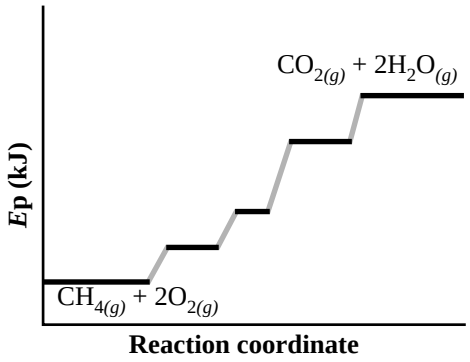
A.



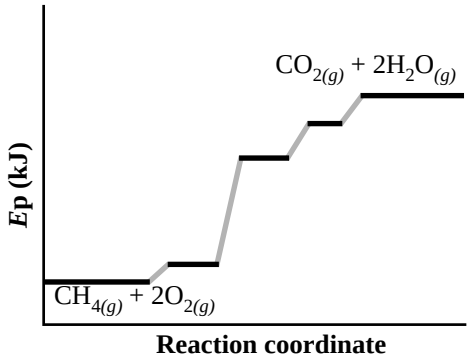
B.



C.



D.



Use the following information to answer the next question.

1	biological decay	**3**	energy from the Sun
2	photosynthesis	**4**	combustion

Numerical Response

4. From the formation of fossil fuels to their eventual use as automobile fuel, the sequence of the above steps, is _____ .

(Record all four digits of your answer on the answer sheet.)

Use the following information to answer the next question.

$$2\,C_{(s)} + 2\,H_{2(g)} + \tfrac{1}{2}O_{2(g)} \rightarrow CH_3CHO_{(l)} + 191.5\ kJ$$

$$CH_3CHO_{(l)} + \tfrac{5}{2}O_{2(g)} \rightarrow 2\,CO_{2(g)} + 2\,H_2O_{(g)} + 1079.1\ kJ$$

11. The molar enthalpy of formation for ethanal, $CH_3CHO_{(l)}$, is

A. +1079.1 kJ/mol

B. +191.5 kJ/mol

C. –191.5 kJ/mol

D. –1079.1 kJ/mol

Nitrogen gas, a stable component of air, reacts with oxygen at high temperatures to produce nitrogen oxides. The energy produced by the combustion of fossil fuels is sufficient to promote the formation of the nitrogen oxides.

$$N_{2(g)} + 2\,O_{2(g)} + 66.4\text{ kJ} \rightarrow 2\,NO_{2(g)}$$

These oxides react with moisture in the air to produce components of acid rain.

Numerical Response

5. The amount of energy involved when one mole of nitrogen dioxide is formed is _____ kJ.

(Record your answer to three digits on the answer sheet.)

12. The equation indicates that the reaction

A. is exothermic

B. is endothermic

C. is releasing energy

D. products have less energy than do the reactants

Use the following information to answer the next question.

$$\tfrac{1}{8}S_{8(s)} + O_{2(g)} \rightarrow SO_{2(g)} \qquad \Delta H = -296.8\text{ kJ}$$

$$\tfrac{1}{8}S_{8(s)} + \tfrac{3}{2}O_{2(g)} \rightarrow SO_{3(g)} \qquad \Delta H = -395.7\text{ kJ}$$

13. The heat of reaction for $SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow SO_{3(g)}$ is

A. –98.9 kJ

B. –692.5 kJ

C. +98.9 kJ

D. +692.5 kJ

Numerical Response

6. Given the reaction

$CaC_{2(s)} + \frac{5}{2}O_{2(g)} \rightarrow CaCO_{3(s)} + CO_{2(g)} \qquad \Delta H = -1537.5$ kJ,

the heat of formation of $CaC_{2(s)}$ is $-$_____ kJ/mol.

(Record your answer to three digits on the answer sheet.)

14. Which of the following reactions is **not** an example of oxidation?

A. Corrosion of metals
B. Plating of metals
C. Rusting of iron
D. The anode half-reaction in a battery

15. The following data were collected during a redox laboratory investigation.

	$W_{(s)}$	$X_{(s)}$	$Q_{(s)}$	$Z_{(s)}$
$W^{-}_{(aq)}$	×	✓	✓	×
$X^{2-}_{(aq)}$	×	×	✓	×
$Q^{2-}_{(aq)}$	×	×	×	×
$Z^{3-}_{(aq)}$	✓	✓	✓	×

Key
✓ evidence of reaction
× no evidence of reaction

In this investigation, the responding variable is the

A. reducing agent
B. oxidizing agent
C. evidence of reaction
D. time required for reaction

16. Which of the following aqueous ions can either gain or lose electrons in a redox reaction?

A. $Sn^{2+}_{(aq)}$

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

C. $Ca^{2+}_{(aq)}$

D. $S^{2-}_{(aq)}$

17. If the lithium reduction half-reaction, $Li^{+}_{(aq)} + e^{-} \rightarrow Li_{(s)}$, had been assigned an $E°$ value of 0.00 V, the predicted $E°_{net}$ value for the reaction $Cu_{(s)} + Zn^{2+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + Zn_{(s)}$ would be

A. +3.38 V

B. –2.28 V

C. –0.42 V

D. –1.10 V

18. The equation representing a spontaneous reaction at standard conditions is

A. $Co^{2+}_{(aq)} + 2\ Fe^{2+}_{(aq)} \rightarrow Co_{(s)} + 2\ Fe^{3+}_{(aq)}$

B. $Sn^{4+}_{(aq)} + 2\ Br^{-}_{(aq)} \rightarrow Sn^{2+}_{(aq)} + Br_{2(l)}$

C. $2\ I^{-}_{(aq)} + Cl_{2(g)} \rightarrow I_{2(s)} + 2\ Cl^{-}_{(aq)}$

D. $Pb_{(s)} + Fe^{2+}_{(aq)} \rightarrow Pb^{2+}_{(aq)} + Fe_{(s)}$

19. Two reagents that will oxidize $Pb_{(s)}$ to $Pb^{2+}_{(aq)}$ but that will **not** oxidize $I^{-}_{(aq)}$ to $I_{2(s)}$ are

A. $F_{2(g)}$ and $Fe^{3+}_{(aq)}$

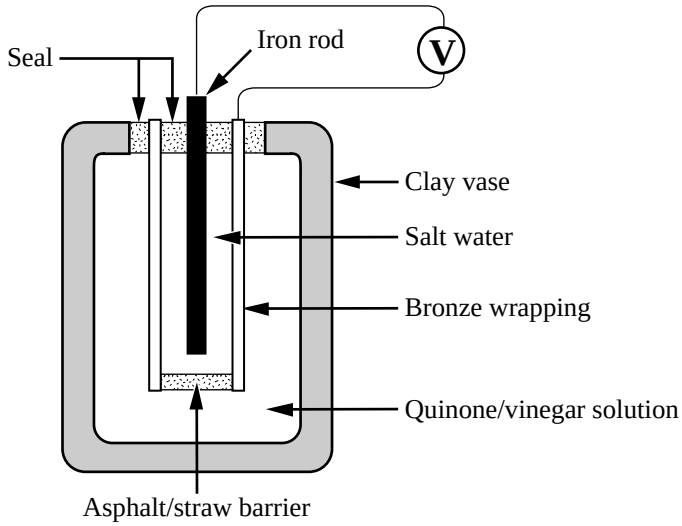
B. $Fe^{3+}_{(aq)}$ and $Br_{2(l)}$

C. $Cd^{2+}_{(aq)}$ and $Ag^{+}_{(aq)}$

D. $Cu^{2+}_{(aq)}$ and $Sn^{4+}_{(aq)}$

In 1936, an object of unknown purpose was discovered near Baghdad. The object was determined to be approximately 2 000 years old. This object had several similarities to modern dry cells, and as a result,was named the "Battery of Baghdad."

It is possible, using materials known to be available 2 000 years ago, to construct a model cell that produces a voltage.



The reaction that occurs in this model cell is

$$Fe_{(s)} + OC_6H_4O_{(aq)} + 2\,H^+_{(aq)} \rightarrow HOC_6H_4OH_{(aq)} + Fe^{2+}_{(aq)} \qquad E°_{net} = 1.25\ V$$

—From *The Committee for the Scientific Investigation of Claims of the Paranormal*

20. The oxidizing agent in the model cell is

A. $Fe_{(s)}$
B. $Fe^{2+}_{(aq)}$
C. $OC_6H_4O_{(aq)}$
D. $HOC_6H_4OH_{(aq)}$

21. The substance acting as the "salt bridge" in the model cell is

A. iron
B. clay
C. bronze
D. asphalt/straw

22. As the model cell operates, one would predict that the quinone/vinegar solution would

A. remain unchanged
B. become less acidic
C. become less basic
D. decrease in pH

23. The model cell

A. proves that cells were used at least 2 000 years ago
B. shows that it is possible to construct a cell from ancient materials
C. disproves the suggestion that cells were available at least 2 000 years ago
D. suggests that alien technology was available in ancient Baghdad

24. The predicted $E°$ under standard conditions for the quinone/vinegar solution half-reaction, $OC_6H_4O_{(aq)} + 2H^+_{(aq)} + 2e^- \rightarrow HOC_6H_4OH_{(aq)}$, is

A. +0.80 V

B. +1.70 V

C. –0.80 V

D. –1.70 V

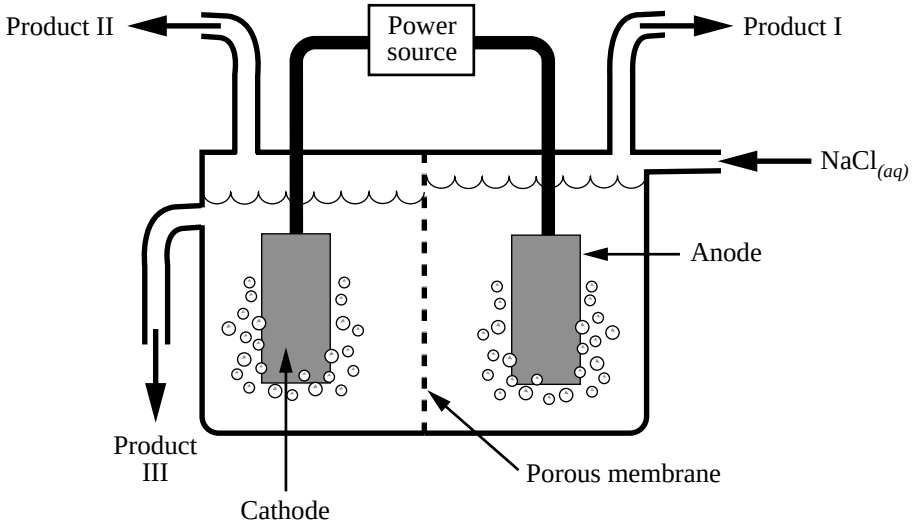
Numerical Response

7. The time in hours that the model cell would have to operate at 10.0 A to consume 35.0 g of $Fe_{(s)}$ is _____ h.

(Record your answer to three digits on the answer sheet.)

Use the following information to answer the next two questions.

This simplified diagram shows the cell used in the Chlor-Alkali process at the Dow Chemical Plant in Fort Saskatchewan, Alberta.



25. The cell shown in the diagram is

A. electrolytic
B. voltaic
C. galvanic
D. acid–base

26. Products I, II, and III from this cell, respectively, are

A. $Cl_{2(g)}$, $H_{2(g)}$, and $HCl_{(aq)}$
B. $H_{2(g)}$, $Cl_{2(g)}$, and $NaOH_{(aq)}$
C. $HCl_{(g)}$, $Cl_{2(g)}$, and $NaOH_{(aq)}$
D. $Cl_{2(g)}$, $H_{2(g)}$, and $NaOH_{(aq)}$

Numerical Response

8. The volume of 0.160 mol/L $K_2Cr_2O_{7(aq)}$ required to completely react with 10.0 mL of acidic 0.881 mol/L $H_2O_{2(aq)}$ is _____ mL.

(Record your answer to three digits on the answer sheet.)

Numerical Response

9. The oxidation numbers of carbon in $HCOOH_{(aq)}$, $C_6H_{12}O_{6(s)}$, $CO_{2(g)}$, and $CHCl_{3(g)}$, respectively, are _____.

(Record all four digits on the answer sheet.)

During respiration, our body's cells metabolize glucose according to the equation

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

27. In this process, glucose undergoes

A. electrolysis
B. photosynthesis
C. oxidation
D. disproportionation

28. The metabolism of glucose could, if unbuffered, cause our blood to

A. become more acidic
B. become more basic
C. remain neutral
D. lose energy

29. Hyperventilation (very rapid, deep breathing) results in rapid loss of $CO_{2(g)}$ from our bodies. During hyperventilation, the pH of blood

A. decreases

B. increases

C. remains at normal levels

D. becomes more dilute

30. One of the buffer systems in the human body is

$$HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} + OH^-{}_{(aq)}.$$

This buffer system would respond to the addition of vinegar, $CH_3COOH_{(aq)}$, by

A. replacing the vinegar with $OH^-{}_{(aq)}$

B. reacting the vinegar with carbonic acid

C. shifting the equilibrium to the right because $[OH^-{}_{(aq)}]$ would decrease

D. shifting the equilibrium to the left, producing more carbonic acid

31. When citric acid combines with water in the mouth, one reaction that occurs is

$$H_3Ct_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2Ct^-{}_{(aq)} + H_3O^+{}_{(aq)}.$$

The conjugate acid–base pairs in this equation are

A. $H_3Ct_{(aq)}$ / $H_3O^+{}_{(aq)}$ and $H_2O_{(l)}$ / $H_2Ct^-{}_{(aq)}$

B. $H_3Ct_{(aq)}$ / $HCt^{2-}{}_{(aq)}$ and $H_3O^+{}_{(aq)}$ / $H_2O_{(l)}$

C. $H_3Ct_{(aq)}$ / $H_2O_{(l)}$ and $H_3O^+{}_{(aq)}$ / $H_2Ct^-{}_{(aq)}$

D. $H_3Ct_{(aq)}$ / $H_2Ct^-{}_{(aq)}$ and $H_3O^+{}_{(aq)}$ / $H_2O_{(l)}$

In Canada, the annual production of ammonia, $NH_{3(g)}$, exceeds that of any other chemical. About one-quarter of it is used directly as fertilizer. The rest is used as a reactant in the production of explosives and chemicals such as nitric acid.

One such reaction,

$$4\,NH_{3(g)} + 5\,O_{2(g)} \rightleftharpoons 4\,NO_{(g)} + 6\,H_2O_{(g)},$$

is vital to the Ostwald synthesis of nitric acid.

32. The equilibrium law expression for this reaction is

A. $K_{eq} = \dfrac{[NO_{(g)}]^4[H_2O_{(g)}]^6}{[NH_{3(g)}]^4[O_{2(g)}]^5}$ **B.** $K_{eq} = \dfrac{[NH_{3(g)}]^4 + [O_{2(g)}]^5}{[NO_{(g)}]^4 + [H_2O_{(g)}]^6}$

C. $K_{eq} = \dfrac{[NH_{3(g)}]^4 + [O_{2(g)}]^5}{[NO_{(g)}]^4[H_2O_{(g)}]^6}$ **D.** $K_{eq} = \dfrac{4[NH_{3(g)}]\,6[H_2O_{(g)}]}{4[NH_{3(g)}]\,5[O_{2(g)}]}$

33. The number of electrons transferred per molecule of $NH_{3(g)}$ reacted is

A. 3 electrons
B. 5 electrons
C. 10 electrons
D. 12 electrons

Use the following information to answer the next question.

$$NH_4^{+}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^{+}{}_{(aq)} + NH_{3(aq)}$$

Numerical Response

10. In a system at equilibrium, the concentration of the $NH_{3(aq)}$ is 0.35 mol/L and the concentration of the $NH_4Cl_{(aq)}$ is 0.25 mol/L. The pH of the $NH_4^{+}{}_{(aq)}$ / $NH_{3(aq)}$ solution is _____.

(Record your answer to three digits on the answer sheet.)

34. The K_b for $NH_{3(aq)}$ is

A. -5.8×10^{-10}

B. 1.0×10^{-14}

C. 1.7×10^{-5}

D. 1.7×10^{9}

Use the following information to answer the next question.

You have been given two unlabelled acidic solutions. One is a weak acid and one is a strong acid, but they have the same pH.

35. Which of the following statements about the two acids is true?

A. The weak acid more easily releases hydrogen ions and is more concentrated than the strong acid.

B. The strong acid more easily releases hydrogen ions and is more concentrated than the weak acid.

C. The weak acid more easily releases hydrogen ions and is less concentrated than the strong acid.

D. The strong acid more easily releases hydrogen ions and is less concentrated than the weak acid.

---

36. Which of the Brønsted–Lowry acids listed below is stronger than $H_2S_{(aq)}$?

A. $HSO_3^-{}_{(aq)}$

B. $HCN_{(aq)}$

C. $HCO_3^-{}_{(aq)}$

D. $HCOOH_{(aq)}$

37. A reaction in which equilibrium favours the products is

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

38. Which of the following substances is amphiprotic?

A. Sodium sulphite

B. Potassium hydrogen sulphite

C. Calcium carbonate

D. Sodium acetate

39. The Cancarb plant in Medicine Hat produces carbon, $C_{(s)}$, from methane gas. To cool the carbon in the production line, it is sprayed with water. In this process, the water becomes increasingly basic. The $[OH^{-}{}_{(aq)}]$ of the resulting solution is 3.2×10^{-4} mol/L. The pH of the solution is

A. 0.50

B. 3.49

C. 10.51

D. 13.50

*Use the answer selected from **Multiple Choice 39** to answer **Multiple Choice 40****.

40. Two indicators, used separately, that could be used to confirm the pH of the solution produced at Cancarb are

A. orange IV and bromocresol green

B. methyl violet and cresol red

C. indigo carmine and 1,3,5–trinitrobenzene

D. phenolphthalein and indigo carmine

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

41. A base is titrated with an acid solution until the indicator changes colour. This change in the colour of the indicator is referred to as the

A. end point

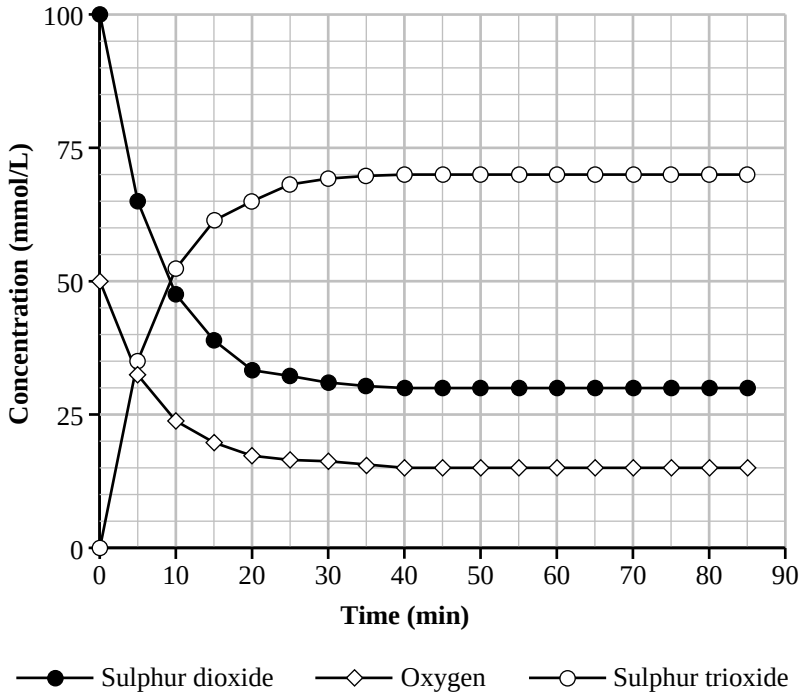
B. equivalence point

C. equilibrium point

D. neutralization point

Use the following information to answer the next question.

The following graph represents the variation over time of the concentrations of $O_{2(g)}$, $SO_{2(g)}$, and $SO_{3(g)}$ for the reaction $2\,SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\,SO_{3(g)}$.



42. Which of the following statements about the graph is true?

A. At t = 0, the concentration of $SO_{2(g)}$ is 30 mmol/L.

B. At equilibrium, the concentration of $SO_{2(g)}$ is 30 mmol/L.

C. At equilibrium, the concentration of $SO_{3(g)}$ is 60 mmol/L.

D. At equilibrium, the concentration of $SO_{3(g)}$ is about half that of $SO_{2(g)}$.

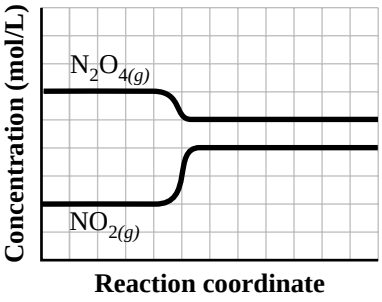
Use the following information to answer the next question.

The graphs below show the relative concentration of $N_2O_{4(g)}$ and $NO_{2(g)}$ as various stresses are exerted on the equilibrium system

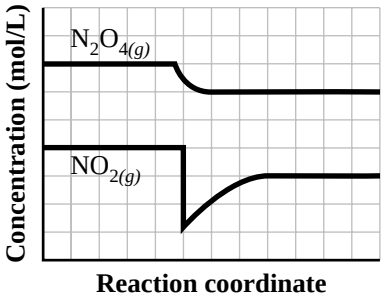
$$N_2O_{4(g)} + \text{heat} \rightleftharpoons 2\,NO_{2(g)}.$$

(Note: The graphs are not drawn to scale.)

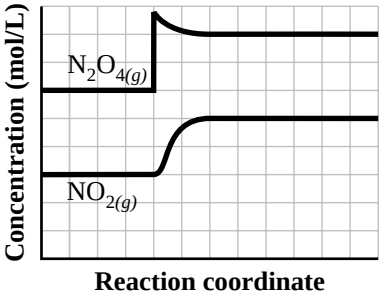
Graph M



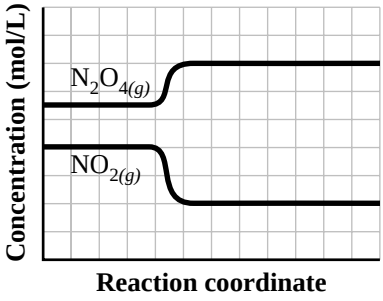
Graph N



Graph O



Graph P



Stresses:

1 removing $NO_{2(g)}$

2 cooling system

3 adding heat

4 adding $N_2O_{4(g)}$

Numerical Response

11. Match each of the graphs with the appropriate stress.

Graph M _____ (Record in column 1)

Graph N _____ (Record in column 2)

Graph O _____ (Record in column 3)

Graph P _____ (Record in column 4)

Anthocyanins (represented as $A^+_{(aq)}$) are responsible for the red colour of wine. Anthocyanins can react with water as follows

$$2\,H_2O_{(l)} + A^+_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + AOH_{(aq)}.$$

The $AOH_{(aq)}$ form is colourless. In a particular white wine sample, the equilibrium $[H_3O^+_{(aq)}]$ is 8.5×10^{-4} mol/L.

Numerical Response

12. The pH of the white wine at equilibrium is _____ .

(Record your answer to three digits on the answer sheet.)

*Use the answer selected from **Numerical Response 12** to answer **Multiple Choice 43****.

43. A few drops of methyl orange indicator were added to the white wine sample. The resulting solution would be

A. colourless
B. yellow
C. orange
D. red

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

44. If the initial concentration of anthocyanins, prior to equilibrium, was 1.62×10^{-3} mol/L, the K_a for anthocyanins is

A. 2.24×10^{3}
B. 1.07×10^{1}
C. 9.38×10^{-4}
D. 4.46×10^{-4}

For Department Use Only

Written Response – 15%

1. A forensic scientist analyzed a pure substance believed to be strychnine, $C_{21}H_{22}N_2O_{2(s)}$, a dibasic substance that reacts completely with $HCl_{(aq)}$. As one of the tests, she titrated samples of the substance with 0.448 mol/L $HCl_{(aq)}$ and obtained the data tabulated below.

	Trial I	**Trial II**	**Trial III**	**Trial IV**
Mass of unidentified sample (g)	5.34	5.34	5.34	5.34
Final buret reading (mL)	28.71	50.00	28.69	47.40
Initial buret reading (mL)	0.00	28.71	0.02	18.68

Could the substance be strychnine?

Your response should include

- appropriate calculations
- justification for your conclusion

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Written Response – 15%

2. Talon Tapes of Edmonton manufactures plastic tape containing small pieces of magnesium. This tape is completely wrapped around iron pipes that will be buried underground. Explain in chemical terms the purpose(s) of each component of the tape. Your response should include relevant half-reactions.

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

Tear-out Page

No marks will be given for work done on this page.

Fold and tear along perforation.

Tear-out Page

No marks will be given for work done on this page.

Fold and tear along perforation.

Credit

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No marks will be given for work done on this page.

CHEMISTRY 30 MULTIPLE-CHOICE KEY

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

* if MC 39 is A, then B
B, then A
C, then D
D, then C

** if NR 12 ≥ 4.4, then B
3.2 < NR 12 < 4.4 then C
≤ 3.2 then D

NUMERICAL-RESPONSE KEY

1. 8.11
2. 45.8
   or if MC 2 is A, NR 1 + 679
   B, NR 1 + 37.7
   C, NR 1 + 22.5
   D, NR 1 + 6.03
3. 3142
4. 3214
5. 33.2
6. 62.9
7. 3.36
8. 18.4
9. 2042
10. 9.38
11. 3142
12. 3.07

SAMPLE ANSWER KEY FOR WRITTEN-RESPONSE QUESTION

The samples that follow represents only one valid approach to each of the problems. During the diploma examination marking session, provision is made for considering various approaches the student may have used.

1. Volume $HCl_{(aq)}$ used

Trial 1	**2**	**3**	**4**
28.71 mL	21.29 mL	28.67 mL	28.72 mL

Discard Trail 2: Average volume $= \frac{28.71 + 28.67 + 28.72}{3}$ mL

$= 28.70$ mL

$$C_{21}H_{22}N_2O_{2(s)} + 2HCl_{(aq)} \rightarrow C_{21}H_{24}N_2O_2^{2+}{}_{(aq)} + 2Cl^-_{(aq)}$$

theoretical mass of strychnine $= 0.02870\ L \times 0.448\ mol/L \times \frac{1}{2} \times 334.45\ g/mol$

$= 2.15$ g

Since the theoretical mass (2.15 g) is not close to the experimental mass (5.34 g) the substance is not likely strychnine.

2. The purpose of the tape is to provide protection from corrosion using two methods. The first is to prevent corrosive reagents such as $O_{2(g)}/H_2O_{(l)}$ from coming in contact with the iron pipe and causing the $Fe_{(s)}$ to corrode or rust.

$$2(Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-)$$
$$4e^- + 2H_2O_{(l)} + O_{2(g)} \rightarrow 4OH^-_{(aq)}$$

net redox reaction $2Fe_{(s)} + 2H_2O_{(l)} + O_{2(g)} \xrightarrow{\text{spont}} 2Fe(OH)_{2(s)}$

In the second method of protection, the magnesium in the tape will act as a sacrificial anode to protect the iron if any breaks occur in the tape exposing the $Fe_{(s)}$ pipe. This works because $Mg_{(s)}$ is a stronger reducing agent than the $Fe_{(s)}$.

$$2(Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2e^-)$$
$$4e^- + 2H_2O_{(l)} + O_{2(g)} \rightarrow 4OH^-_{(aq)}$$

net redox reaction $2Mg_{(s)} + 2H_2O_{(l)} + O_{2(g)} \xrightarrow{\text{spont}} 2Mg(OH)_{2(s)}$