January 2000

Chemistry 30

Grade 12 Diploma Examination

Alberta
LEARNING

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Chemistry 30

Grade 12 Diploma Examination

Description

Time: 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, 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 is 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 Learning.
- 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.**

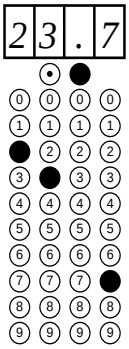
Examples

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

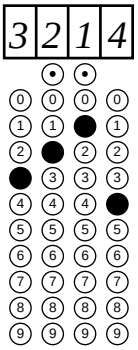
When the following subjects are arranged in alphabetical order, the order is ____ , ____ , ____ , and ____ .

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.

Use the following information to answer the first question.

In most plants, solar energy, water, and carbon dioxide react to form glucose. The reaction is represented by the equation

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

1. This reaction is an example of

A. respiration

B. photosynthesis

C. redox and neutralization

D. combustion and respiration

---

2. A stainless steel spoon is used to stir a cup of hot coffee. In this system, the

A. temperature of the coffee will drop because an endothermic phase change occurs

B. gain in kinetic energy of the spoon is dependent only on how fast the coffee is stirred

C. potential energy lost by the coffee is equal to the potential energy gained by the spoon

D. temperature change of the coffee is directly proportional to the mass and specific heat capacity of the spoon

Novacor is a large international company that produces ethene ($C_2H_{4(g)}$) from ethane ($C_2H_{6(g)}$) at its plant in Joffre, Alberta. The essential process in the conversion of ethane to ethene is called cracking, which involves the removal of hydrogen atoms from ethane molecules. The cracking occurs in special alloy pipes at temperatures near 1 100°C. The process results in the formation of ethene and other byproducts.

3. When 10.0 g of ethane gas was originally formed from its elements, the decrease in enthalpy was

A. 3.92 kJ

B. 28.2 kJ

C. 84.7 kJ

D. 255 kJ

4. Liquid ethane, at a pressure of approximately 5 000 kPa and a temperature of –35°C, enters the plant via a pipeline. It passes through a series of heat exchangers and eventually emerges as a gas at 900 kPa and 35°C. This change in the ethane is primarily due to

A. an increase in potential energy and kinetic energy

B. an increase in potential energy only

C. a decrease in density and kinetic energy

D. an increase in density, potential energy, and kinetic energy

Use the following information to answer the next question.

Coke (carbon) deposits formed on the inside of the alloy pipes must be periodically removed by a process known as decoking. Passing air and steam through the pipes results in the combustion of the coke according to the equation

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$$

5. The decoking process is an oxidation–reduction reaction. The reaction that occurs in the human body in which carbon undergoes the same change in assigned oxidation number as in the decoking process is

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

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

C. $C_2H_5OH_{(l)} \rightarrow C_2H_4O_{(l)} + H_{2(g)}$

D. $C_2H_5OH_{(l)} \rightarrow C_2H_{4(g)} + H_2O_{(l)}$

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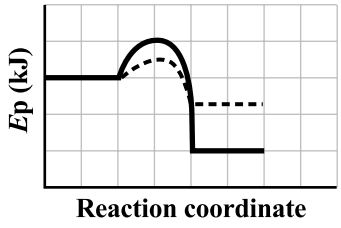
6. One of the byproducts of the cracking process used at Novacor is ethyne ($C_2H_{2(g)}$). In the presence of a palladium catalyst, the ethyne forms ethene and ethane. This reaction is represented by the **unbalanced** equation

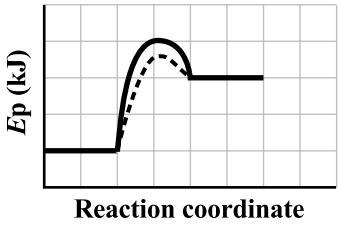
$$C_2H_{2(g)} + H_{2(g)} \rightarrow C_2H_{4(g)} + C_2H_{6(g)} + \text{energy}$$

The energy diagram that represents both the catalyzed (– – – –) and uncatalyzed reactions (——) is

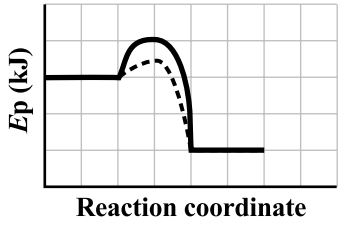
A.



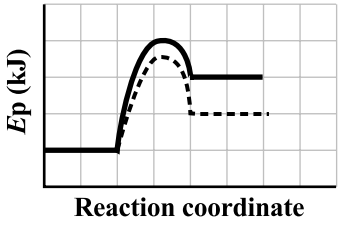
B.



C.



D.



Use the following information to answer the next two questions.

Novacor obtains caustic soda solution from a company that electrolyzes brine ($NaCl_{(aq)}$).

7. The primary reaction that occurs at the anode during the electrolysis of $NaCl_{(aq)}$ is

A. $2\,H_2O_{(l)} + 2\,e^- \rightarrow H_{2(g)} + 2\,OH^-_{(aq)}$

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

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

D. $2\,H_2O_{(l)} \rightarrow 4\,H^+_{(aq)} + O_{2(g)} + 4\,e^-$

*Use your recorded answer from **Multiple Choice 7** to answer **Multiple Choice 8**.**

8. A small sample of the anode product is tested. The predicted test result is that

A. a glowing splint will reignite

B. red litmus paper will turn white

C. red litmus paper will turn blue

D. the product will react vigorously with water

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

Use the following information to answer the next two questions.

After the ethene is separated from the byproducts of the cracking process, it is washed with a caustic soda solution ($NaOH_{(aq)}$).

Numerical Response

1. A lab technician titrated 10.0 mL of a 2.57 mol/L caustic soda solution with a 0.860 mol/L standardized $HCl_{(aq)}$ solution. The volume of $HCl_{(aq)}$ needed to completely neutralize the caustic soda solution is _____ mL.

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

9. The indicator that would best identify the equivalence point of this titration is

A. methyl violet
B. bromocresol green
C. bromothymol blue
D. 1,3,5–trinitrobenzene

10. When energy changes are arranged in **decreasing** order of magnitude, the order is

A. phase, chemical, nuclear fusion
B. nuclear fusion, phase, chemical
C. chemical, nuclear fusion, phase
D. nuclear fusion, chemical, phase

11. When hydrogen in the sun is converted into helium, the changes involve primarily

A. intermolecular forces
B. intramolecular forces
C. nuclear forces
D. chemical bonds

Use the following information to answer the next question.

Statements Regarding Fossil Fuel Use

I The combustion of these fuels contributes to the greenhouse effect.
II Locating, extracting, and transporting fossil fuels causes environmental damage.
III The energy yield from fossil fuels is low, thus they are poor energy sources.
IV Fossil fuels are a non-renewable resource.

12. The statement about fossil fuel use that is **least** accurate is statement

A. I

B. II

C. III

D. IV

Use the following information to answer the next question.

A student made the following four statements about a chemical reaction.

I The reaction is exothermic.
II The reaction has a negative ΔH value.
III The reaction warms up the surroundings.
IV The enthalpy of the products is greater than that of the reactants.

13. Which statement is **not** consistent with the other three?

A. Statement I

B. Statement II

C. Statement III

D. Statement IV

14. Of the following metallic oxides, the one that would require the greatest energy per mole to decompose into its constituent elements is

A. $SnO_{(s)}$

B. $PbO_{(s)}$

C. $Fe_2O_{3(s)}$

D. $MnO_{(s)}$

Numerical Response

2. The molar enthalpy for the fusion of water is +/–_____ kJ/mol.

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

Use the following information to answer the next question.

A student performed a calorimetry experiment and recorded the data below.

Mass of aluminum calorimeter	470.0 g
Mass of calorimeter water	100.0 g
Initial temperature of calorimeter water	23.0 °C
Mass of silicon	52.0 g
Initial temperature of silicon	61.6 °C
Final temperature of calorimeter, water, and silicon	24.6 °C

15. The amount of energy lost by silicon in the experiment is

A. 670 J

B. 1.35 kJ

C. 2.25 kJ

D. 3.82 kJ

Ethanol is the alcohol found in beer, wine, and whisky. In the production of ethanol, the starch in barley, grapes, or corn, is reacted to form glucose in the presence of enzymes. During the fermentation process, yeast is added to the glucose. The yeast contains enzymes that act as biological catalysts in the reaction of glucose into ethanol and carbon dioxide. The reaction is represented by the equation

$$C_6H_{12}O_{6(s)} \rightarrow 2\,CO_{2(g)} + 2\,C_2H_5OH_{(l)}$$

Numerical Response

3. The molar enthalpy of reaction for the fermentation of glucose is +/–_____ kJ/mol.

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

16. In industry, ethanol is produced by a catalyzed reaction between ethene and water. The equation and energy associated with this reaction can be represented as

A. $C_2H_{4(g)} + H_2O_{(l)} \rightarrow C_2H_5OH_{(l)} + 87.6\text{ kJ}$

B. $C_2H_{4(g)} + H_2O_{(l)} + 43.6\text{ kJ} \rightarrow C_2H_5OH_{(l)}$

C. $C_2H_{4(g)} + H_2O_{(l)} \rightarrow C_2H_5OH_{(l)} \qquad \Delta H = +87.6\text{ kJ}$

D. $C_2H_{4(g)} + H_2O_{(l)} \rightarrow C_2H_5OH_{(l)} \qquad \Delta H = -43.6\text{ kJ}$

17. When ethanol is burned in the body, it is

A. reduced in an endothermic reaction

B. oxidized in an endothermic reaction

C. oxidized in an exothermic reaction

D. reduced in an exothermic reaction

Use the following information to answer the next question.

The energy from cellular respiration is stored in the form of ATP (adenosine triphosphate) molecules in cells. As energy is required by a cell, it is released from the ATP molecules as they react to form ADP (adenosine diphosphate) molecules. The reaction is represented by the equilibrium equation

$$ATP_{(aq)} \rightleftharpoons ADP_{(aq)} + PO_4^{3-}{}_{(aq)} + 30.5\ kJ$$

Cells contain large numbers of ADP and ATP molecules.

Numerical Response

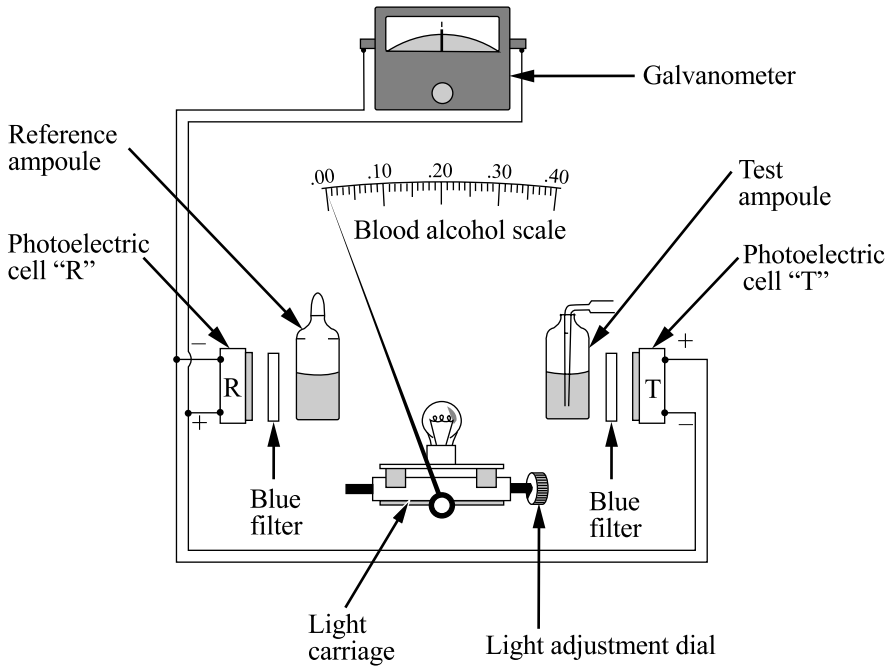
4. When you are reading, you use 400 kJ/h of energy. In one hour, the number of moles of ATP reacted to form ADP is _____ mol.

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

Use the following information to answer the next question.

A breathalyzer contains a reference ampoule and a test ampoule, each containing acidified potassium dichromate solution. As alcohol in a person's breath is exhaled into the breathalyzer, the test ampoule solution changes colour. This reaction is represented by the **unbalanced** equation

$$Cr_2O_7^{2-}{}_{(aq)} + C_2H_5OH_{(l)} + H^+{}_{(aq)} \rightarrow Cr^{3+}{}_{(aq)} + H_2O_{(l)} + CH_3COOH_{(aq)}$$



—from Glen Aikenhead, 1991

18. When alcohol reacts in the test ampoule, the pH of the solution

A. remains the same

B. decreases as $H^+{}_{(aq)}$ is consumed

C. increases as $H^+{}_{(aq)}$ is consumed

D. decreases as $CH_3COOH_{(aq)}$ is produced

Use the following information to answer the next question.

When you drink alcoholic beverages, only 5% of the alcohol is removed through functions such as breathing and sweating. Your liver is responsible for eliminating the other 95%. The alcohol reacts with $NAD^+_{(aq)}$, a substance present in the liver. The reaction is catalyzed by an enzyme called alcohol dehydrogenase and is represented by the equation

$$C_2H_5OH_{(l)} + NAD^+_{(aq)} \xrightarrow[\text{dehydrogenase}]{\text{alcohol}} CH_3CHO_{(aq)} + NADH_{(aq)} + H^+_{(aq)} + \text{energy}$$

19. If you had a low level of the biological catalyst, alcohol dehydrogenase,

A. you would feel hotter than normal

B. the concentration of $NADH_{(aq)}$ would increase

C. your blood alcohol level would decrease at a faster rate than normal

D. your blood alcohol level would remain high for a longer period than normal

---

20. A student mixes 41.8 g of ethanol at 15.8°C with 50.7 g of water at 49.2°C. If the resulting temperature of the solution is 38.4°C, what is the specific heat capacity of the ethanol?

A. 2.43 J/(g·°C)

B. 3.45 J/(g·°C)

C. 4.19 J/(g·°C)

D. 6.51 J/(g·°C)

Use the following information to answer the next question.

Ethanol reacts with acidified permanganate ion, as represented by the equation

$$5\,C_2H_5OH_{(l)} + 4\,MnO_4^-{}_{(aq)} + 12\,H^+{}_{(aq)} \rightarrow 5\,CH_3COOH_{(aq)} + 4\,Mn^{2+}{}_{(aq)} + 11\,H_2O_{(l)}$$

21. In this reaction, the oxidation number for the oxidizing agent changes from

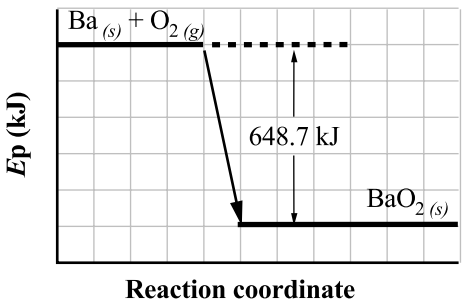
A. +7 to +2

B. +28 to +8

C. +2 to 0

D. +10 to 0

Use the following graph to answer the next question.



Numerical Response

5. According to the information shown above and in the data booklet, ΔH of reaction for $BaO_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow BaO_{2(s)}$ is +/–_____ kJ.

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

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22. In a voltaic cell, there is a conversion of

A. chemical energy to electrical energy in a spontaneous change
B. chemical energy to electrical energy in a non-spontaneous change
C. electrical energy to chemical energy in a spontaneous change
D. electrical energy to chemical energy in a non-spontaneous change

23. Which of the following reducing agents is the strongest?

A. $I^-_{(aq)}$
B. $Br_{2(l)}$
C. $H_2O_{(l)}$
D. $Al_{(s)}$

Use the following equations to answer the next question.

1 $Fe^{2+}_{(aq)} + Cr^{3+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + Cr^{2+}_{(aq)}$

2 $NH_{3(aq)} + H_2O_{(l)} \rightarrow NH_4^{+}{}_{(aq)} + OH^{-}_{(aq)}$

3 $2\,NH_{3(g)} + \frac{7}{2}O_{2(g)} \rightarrow 2\,NO_{2(g)} + 3\,H_2O_{(g)}$

4 $Mg^{2+}_{(aq)} + 2\,OH^{-}_{(aq)} \rightarrow Mg(OH)_{2(s)}$

5 $Sn^{2+}_{(aq)} + 2\,NO_3^{-}{}_{(aq)} + 4\,H^{+}_{(aq)} \rightarrow Sn^{4+}_{(aq)} + 2\,NO_{2(g)} + 2\,H_2O_{(l)}$

6 $PbSO_{4(s)} + SO_3^{2-}{}_{(aq)} + 2\,OH^{-}_{(aq)} \rightarrow H_2O_{(l)} + Pb_{(s)} + 2\,SO_4^{2-}{}_{(aq)}$

Numerical Response

6. The equations that represent oxidation–reduction reactions, listed in any order, are _____ , _____ , _____ , and _____ .

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

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24. The oxidation number of Mo in $CaMoO_{4(s)}$ is

A. +2

B. +4

C. +6

D. –2

Corrosion of iron costs the public millions of dollars annually. The corrosion process can be simply represented by two half-reactions:

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

The $Fe(OH)_{2(s)}$ that forms is further oxidized by $O_{2(g)}$ in the presence of water to form rust, a mixture of hydrated oxides that is represented by the general formula $Fe_2O_3 \cdot x\,H_2O_{(s)}$.

One region on the iron surface acts as the anode, and another region, where the wet iron is exposed to oxygen, acts as the cathode.

Unfortunately, it is not possible to gain permission for electronic publication of all the source material for this question.

25. Under standard conditions, the net voltage for the oxidation–reduction reaction that results in the formation of $Fe(OH)_{2(s)}$ is

A. –0.85 V

B. +0.85 V

C. –1.30 V

D. +1.30 V

26. Iron is often alloyed with zinc to minimize corrosion. The zinc in the alloy acts as the

A. anode and is oxidized

B. anode and is reduced

C. cathode and is oxidized

D. cathode and is reduced

27. Salt spread on highways during the winter months increases the rate of rust formation on cars because the salt

A. reacts with the rust to form iron salts

B. reacts with the iron salts to form iron

C. increases the conductivity of the electrolyte solution

D. decreases the conductivity of the electrolyte solution

Numerical Response

7. Under standard conditions, hydrogen gas reacts with $Au^{3+}_{(aq)}$ ions to produce $Au_{(s)}$. The net cell potential for the reaction is +/–_____ V.

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

Use the following information to answer the next question.

The reactions below involve hypothetical metals and metallic ions.

Reaction	**Observation**
$Z^{3+}_{(aq)} + X_{(s)}$	no evidence of reaction
$X^{2+}_{(aq)} + D_{(s)}$	evidence of reaction
$D^{+}_{(aq)} + A_{(s)}$	evidence of reaction
$Z^{3+}_{(aq)} + D_{(s)}$	no evidence of reaction
$A^{2+}_{(aq)} + Z_{(s)}$	no evidence of reaction

28. The order of oxidizing agents, from strongest to weakest, is

A. $X^{2+}_{(aq)}$, $Z^{3+}_{(aq)}$, $A^{2+}_{(aq)}$, $D^{+}_{(aq)}$

B. $A^{2+}_{(aq)}$, $Z^{3+}_{(aq)}$, $D^{+}_{(aq)}$, $X^{2+}_{(aq)}$

C. $Z^{3+}_{(aq)}$, $X^{2+}_{(aq)}$, $A^{2+}_{(aq)}$, $D^{+}_{(aq)}$

D. $X^{2+}_{(aq)}$, $D^{+}_{(aq)}$, $Z^{3+}_{(aq)}$, $A^{2+}_{(aq)}$

Vinegar, an aqueous solution of acetic acid, is used to preserve and flavour food. Most of the vinegar used for this purpose has an acetic acid concentration of 0.83 mol/L.

29. The vinegar used in food has a

A. $[H_3O^+_{(aq)}]$ equal to $[CH_3COO^-_{(aq)}]$

B. $[H_3O^+_{(aq)}]$ greater than $[CH_3COOH_{(aq)}]$

C. $[CH_3COO^-_{(aq)}]$ equal to $[CH_3COOH_{(aq)}]$

D. $[CH_3COO^-_{(aq)}]$ greater than $[H_3O^+_{(aq)}]$

30. The $[H_3O^+_{(aq)}]$ of the 0.83 mol/L $CH_3COOH_{(aq)}$ is

A. 8.3×10^{-1} mol/L

B. 3.9×10^{-3} mol/L

C. 1.8×10^{-5} mol/L

D. 1.5×10^{-5} mol/L

*Use your recorded answer from **Multiple Choice 30** to answer **Numerical Response 8**.**

Numerical Response

8. The pH of the vinegar is _____ .

(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.**

31. Pickling vinegar has a pH of 2.37. When 3 drops of bromocresol green and 3 drops of phenolphthalein are added to a sample of this vinegar, the resulting colour of the solution is

A. yellow

B. green

C. blue

D. purple

32. Vinegar ($CH_3COOH_{(aq)}$) and baking soda ($NaHCO_{3(s)}$) are added to recipes to produce baked products with light, fluffy textures. The net ionic equation for the reaction that occurs is

A. $H_3O^+_{(aq)} + HCO_3^-{}_{(aq)} \rightarrow CO_{2(g)} + 2\,H_2O_{(l)}$

B. $HCO_3^-{}_{(aq)} + CH_3COO^-_{(aq)} \rightarrow CH_3COOH_{(aq)} + CO_3^{2-}{}_{(aq)}$

C. $CH_3COOH_{(aq)} + NaHCO_{3(aq)} \rightarrow NaCH_3COO_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

D. $CH_3COOH_{(aq)} + HCO_3^-{}_{(aq)} \rightarrow CH_3COO^-_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

Use the following equation to answer the next two questions.

$$HNO_{2(aq)} + H_2BO_3^-{}_{(aq)} \rightleftharpoons NO_2^-{}_{(aq)} + H_3BO_{3(aq)}$$

33. A conjugate acid–base pair in the reaction is

A. $H_2BO_3^-{}_{(aq)}$ and $NO_2^-{}_{(aq)}$

B. $H_3BO_{3(aq)}$ and $H_2BO_3^-{}_{(aq)}$

C. $HNO_{2(aq)}$ and $H_2BO_3^-{}_{(aq)}$

D. $H_3BO_{3(aq)}$ and $NO_2^-{}_{(aq)}$

34. The amphiprotic species in the reaction is

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

B. $HNO_{2(aq)}$

C. $NO_2^-{}_{(aq)}$

D. $H_3BO_{3(aq)}$

Solutions of carbolic acid, commonly known as phenol ($HC_6H_5O_{(aq)}$), are widely used as disinfectants. One such solution has a concentration of 6.44×10^{-2} mol/L and a pH of 5.60. Carbolic acid dissociates in water according to the equation

$$HC_6H_5O_{(aq)} + H_2O_{(l)} \rightleftharpoons C_6H_5O^-_{(aq)} + H_3O^+_{(aq)}$$

35. The K_a expression for the equation is

A. $K_a = \dfrac{[C_6H_5O^-_{(aq)}][H_3O^+_{(aq)}]}{[HC_6H_5O_{(aq)}][H_2O_{(l)}]}$

B. $K_a = \dfrac{[HC_6H_5O_{(aq)}][H_2O_{(l)}]}{[C_6H_5O^-_{(aq)}][H_3O^+_{(aq)}]}$

C. $K_a = \dfrac{[C_6H_5O^-_{(aq)}][H_3O^+_{(aq)}]}{[HC_6H_5O_{(aq)}]}$

D. $K_a = \dfrac{[HC_6H_5O_{(aq)}]}{[C_6H_5O^-_{(aq)}][H_3O^+_{(aq)}]}$

36. The K_a for this carbolic acid is

A. 6.3×10^{-12}

B. 9.8×10^{-11}

C. 2.5×10^{-6}

D. 3.9×10^{-5}

37. In the *CRC Handbook of Chemistry and Physics*, the K_a for carbolic acid at 20.0°C is 1.3×10^{-10}. The K_b for $C_6H_5O^-_{(aq)}$ is

A. 1.1×10^{-12}

B. 1.1×10^{-5}

C. 7.7×10^{-5}

D. 1.3×10^{-10}

*Use your recorded answer from **Multiple Choice 37** to answer **Numerical Response 9**.**

Numerical Response

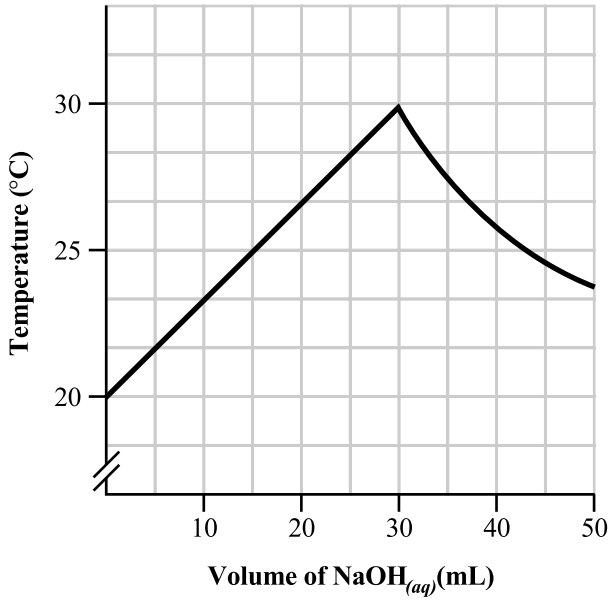
9. The pOH of 0.10 mol/L $NaC_6H_5O_{(aq)}$ at 20.0°C is _____ .

(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 graph to answer the next question.

Thermometric Titration of 20.0 mL of 0.20 mol/L $HCl_{(aq)}$ with $NaOH_{(aq)}$



Numerical Response

10. This experiment is an example of a thermometric titration in which a change in temperature occurs as the reagents react. The $[NaOH_{(aq)}]$ for this titration is _____ mol/L.

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

Use the following information to answer the next three questions.

Titration of 20.0 mL Samples of Acidified $H_2O_{2(l)}$ with 0.15 mol/L $KMnO_{4(aq)}$

Trial	**I**	**II**	**III**	**IV**
Final buret volume (mL)	18.3	34.6	17.4	33.8
Initial buret volume (mL)	0.4	18.3	0.9	17.4
Colour at endpoint	purple	pink	pink	pink

38. The balanced equation for the titration is

A. $2\,MnO_4^-{}_{(aq)} + 16\,H^+{}_{(aq)} + 5\,H_2O_{2(l)} \rightarrow 2\,Mn^{2+}{}_{(aq)} + 8\,H_2O_{(l)} + 5\,O_{2(g)}$

B. $2\,MnO_4^-{}_{(aq)} + 6\,H^+{}_{(aq)} + 5\,H_2O_{2(l)} \rightarrow 2\,Mn^{2+}{}_{(aq)} + 4\,H_2O_{(l)} + O_{2(g)}$

C. $2\,MnO_4^-{}_{(aq)} + 6\,H^+{}_{(aq)} + 5\,H_2O_{2(l)} \rightarrow 2\,Mn^{2+}{}_{(aq)} + 3\,H_2O_{(l)} + 5\,O_{2(g)}$

D. $2\,MnO_4^-{}_{(aq)} + 6\,H^+{}_{(aq)} + 5\,H_2O_{2(l)} \rightarrow 2\,Mn^{2+}{}_{(aq)} + 8\,H_2O_{(l)} + 5\,O_{2(g)}$

Numerical Response

11. The volume of potassium permanganate that should be used in subsequent calculations is _____ mL.

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

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

Numerical Response

12. The hydrogen peroxide concentration is _____ mol/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.**

Beverages such as carbonated soft drinks contain carbonic acid. In addition, citric acid and phosphoric acid are often added to ensure that the pH is below 4.5. This is considered the "safety zone" for these beverages because below this pH, the risk of microbial contamination is very low.

39. The equation representing the equilibrium of phosphoric acid is

A. $H_3PO_{4(aq)} + H_2O_{(l)} \rightleftharpoons H_2PO_4^-{}_{(aq)} + OH^-{}_{(aq)}$

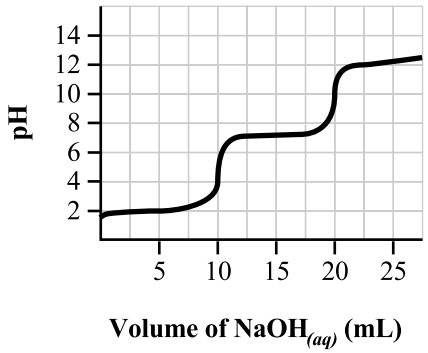
B. $H_3PO_{4(aq)} \rightleftharpoons H_3O^+{}_{(aq)} + PO_3^-{}_{(aq)}$

C. $H_3PO_{4(aq)} \rightleftharpoons 3\,H^+{}_{(aq)} + PO_4^{3-}{}_{(aq)}$

D. $H_3PO_{4(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+{}_{(aq)} + H_2PO_4^-{}_{(aq)}$

Use the following information to answer the next question.

A student sketched a titration curve based on data collected during a reaction between 0.050 mol/L $NaOH_{(aq)}$ titrant and a 25.0 mL sample of a soft drink.



40. The most suitable indicator to identify the equivalence point of the second reaction is

A. phenolphthalein

B. bromothymol blue

C. methyl red

D. methyl orange

41. A glass of orange juice contains enough hydronium ions to kill you if your blood is not buffered to a pH of about 7.35. One of the several buffer systems that your blood contains is $H_2PO_4^-{}_{(aq)} - HPO_4^{2-}{}_{(aq)}$. This system initially buffers the addition of hydronium ions from orange juice by the reaction

A. $H_3O^+{}_{(aq)} + H_2PO_4^-{}_{(aq)} \rightleftharpoons H_3PO_{4(aq)} + H_2O_{(l)}$

B. $H_3O^+{}_{(aq)} + HPO_4^{2-}{}_{(aq)} \rightleftharpoons H_2PO_4^-{}_{(aq)} + H_2O_{(l)}$

C. $2\,H_3O^+{}_{(aq)} + PO_4^{3-}{}_{(aq)} \rightleftharpoons H_2PO_4^-{}_{(aq)} + H_2O_{(l)}$

D. $2\,H_3O^+{}_{(aq)} + 2\,H_2PO_4^-{}_{(aq)} \rightleftharpoons PO_4^{3-}{}_{(aq)} + 2\,H_2O_{(l)}$

Hot tub owners can control disease-causing bacteria and algae by adding solid sodium hypochlorite pellets, $NaClO_{(s)}$, to the water. This results in the formation of $HClO_{(aq)}$, as represented by the equilibrium

$$ClO^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HClO_{(aq)} + OH^-{}_{(aq)}$$

Undissociated $HClO_{(aq)}$ effectively kills bacteria and algae. A pH of 7.40 is considered ideal for a hot tub.

42. Ideally, the water in a hot tub has a hydronium ion concentration of

A. 4.0×10^{-8} mol/L and is basic

B. 2.5×10^{-7} mol/L and is basic

C. 4.0×10^{-8} mol/L and is acidic

D. 2.5×10^{-7} mol/L and is acidic

43. If the hot tub contains 1.20 Mg of water, then the energy required to warm the water from 12.0°C to 40.0°C is

A. 6.74×10^7 J

B. 8.99×10^7 J

C. 1.41×10^8 J

D. 1.60×10^8 J

44. When using a hot tub, bathers release substances from their bodies into the water that result in an increase in the pH of the water. As the pH increases, there is

A. an increase in $[H_3O^+_{(aq)}]$, which results in an equilibrium shift that is more favourable to bacterial growth

B. a decrease in $[H_3O^+_{(aq)}]$, which results in an equilibrium shift that is more favourable to bacterial growth

C. an increase in $[H_3O^+_{(aq)}]$, which results in an equilibrium shift that is less favourable to bacterial growth

D. a decrease in $[H_3O^+_{(aq)}]$, which results in an equilibrium shift that is less favourable to bacterial growth

The written-response questions follow on the next page.

In the table below, the time, in hours, that each of three cells would operate four particular devices is given. The cost of each cell is also given.

	Type of D Cell		
	Leclanché	Zinc Chloride	Alkaline
Motor Toy	1.0 h	3.0 h	11.0 h
Cassette Player	1.0 h	2.5 h	5.7 h
Flashlight	1.0 h	2.0 h	4.6 h
Pocket Radio	1.0 h	1.8 h	4.1 h
Cost of Cell:	$0.75	$0.95	$2.25

Leclanché Cell ($Zn_{(s)}/MnO_{2(s)}$)

Overall Reaction

$$2\,MnO_{2(s)} + 2\,NH_4Cl_{(aq)} + Zn_{(s)} \rightarrow ZnCl_2 \cdot 2\,NH_{3(s)} + Mn_2O_3 \cdot H_2O_{(s)}$$

Operating Temperature Range –5°C to 55°C
Voltage 1.5 V

Zinc Chloride Cell ($Zn_{(s)}/MnO_{2(s)}$)

Overall Reaction

$$8\,MnO_{2(s)} + 4\,Zn_{(s)} + ZnCl_{2(s)} + 9\,H_2O_{(l)} \rightarrow 8\,MnOOH_{(s)} + ZnCl_2 \cdot 4\,ZnO \cdot 5\,H_2O_{(s)}$$

Operating Temperature Range –20°C to 55°C
Voltage 1.5 V

Alkaline/Manganese Dioxide Cell ($Zn_{(s)}/MnO_{2(s)}$)

Overall Reaction

$$2\,Zn_{(s)} + 3\,MnO_{2(s)} \rightarrow 2\,ZnO_{(s)} + Mn_3O_{4(s)}$$

Operating Temperature Range –30°C to 55°C
Voltage 1.5 V

Written Response – 15%

1. **a.** Identify the anode common to all of the D cells. Indicate the change in oxidation number for the anode.

b. For how many hours could a Leclanché cell operate at 0.300 A if the limiting reagent was a 10.0 g anode?

c. Which type of D cell battery would you use to operate a portable cassette player outside on a mild winter day when the temperature was −12°C? Justify your choice from two different perspectives.

Written Response – 15%

2. Identify a stress that would shift the following equilibrium system to favour the products.

$$2\,NO_{2(g)} \rightleftharpoons N_2O_{4(g)} + 101.4\ kJ$$

brown colourless

Your response should include

- an explanation, based on Le Châtelier's principle, of how the stress would shift this equilibrium
- a procedure that would demonstrate the effect of applying the stress
- a prediction of what evidence there would be that the shift had occurred

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

Credits

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Tear-out Page

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

Fold and tear along perforation.

Multiple-Choice

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

Numerical Response

1.	29.9	**7.**	1.50
2.	6.03	**8.**	2.41†
3.	68.1	**9.**	2.56‡
4.	13.1	**10.**	0.13
5.	95.2	**11.**	16.4
6.	1356	**12.**	0.31§

Links:

*If MC 7 was A, then MC 8 is C
B, then MC 8 is D
C, then MC 8 is B*
D, then MC 8 is A

†If MC 30 was A, then NR 8 is 0.08
B, then NR 8 is 2.41†
C, then NR 8 is 4.74
D, then NR 8 is 4.82

‡If MC 37 was A, then NR 9 is 6.48
B, then NR 9 is 2.98
C, then NR 9 is 2.56‡
D, then NR 9 is 5.44

§NR 12 = NR 11 × 0.01875

SAMPLE ANSWER KEY FOR WRITTEN-RESPONSE QUESTIONS

The samples that follow represent 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. **a.** The anode is zinc metal. The change in oxidation number is from 0 to +2.

b.

$$t = \frac{n_{e^-} \times F}{I}$$

$$t = \frac{\frac{2}{1}(10.0\text{ g} / 65.38\text{ g/mol})(9.65 \times 10^4\text{ C/mol})}{0.300\text{ A}}$$

$$t = 9.84 \times 10^4\text{ s} \times \frac{\text{h}}{3\,600\text{ s}}$$

$$t = 27.3\text{ h}$$

c. Zinc chloride because it will operate at –12°C and it is cheaper per unit time for the life of the battery $\left(\frac{5.7}{2.5}\right)$ 95¢ = \$2.17 vs. \$2.25. (cost is 38¢/h Vs 39¢/h for the alkaline cell)

or

Alkaline because it will operate at –12°C and it creates less waste since one cell lasts over twice as long as the zinc chloride, thus half the waste will be generated.

2. Valid stresses:

- add $NO_{2(g)}$
- remove $N_2O_{4(g)}$
- increase pressure or decrease volume
- lower temperature

Sample Procedure:

- observe the colour of the gas in a $NO_{2(g)} - N_2O_{4(g)}$ equilibrium tube at room temperature
- the bulb could now be put in a cold water bath and the colour change observed

Explanation of Le Châtelier's Principle

- when the bulb is put in the cold water it will turn a lighter brown because the removal of energy will make the exothermic reaction predominate which will make the equilibrium shift to produce more $N_2O_{4(g)}$ (colourless).

Predicted Evidence

- brown colour diminishes
- temperature increases
- pressure decreases