Many of these questions are in the style of the Diploma Exam. You will find guidance for writing Diploma Exams in Appendix H. Exam study tips and test-taking suggestions are on the Nelson Web site. Science Directing Words used in Diploma Exams are in bold type.

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DO NOT WRITE IN THIS TEXTBOOK.

Part 1

1. A solution such as tap water is a
- A. pure substance
- B. compound
- C. homogeneous mixture
- D. heterogeneous mixture

Use this information to answer questions 2 and 3.

Iodine dissolved in alcohol is used as an external medication for its disinfecting and antibacterial properties. To study these effects, 4.52 g of pure iodine is dissolved in 150 mL of alcohol.

2. Evidence for the dissolving of iodine can be obtained from all of the following **except** the
- A. change in conductivity of the solution
- B change in colour of the solution
- C. change in density of the solution
- D. heat transferred during the dissolving process

3. NR The amount concentration of the iodine solution is _____ mmol/L.

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4. NR A sample of lake water contains 405 mg of dissolved minerals in 2.50 L of lake water. The concentration of dissolved minerals in parts per million is _____ ppm.

5. Dilution of stock solutions is an essential laboratory skill. If a lab technician needs to prepare 2.00 L of 2.50 mol/L ammonia solution, what volume of 14.8 mol/L concentrated ammonia will he require?
- A. 11.8 mL
- B. 33.8 mL
- C. 169 mL
- D. 338 mL

6. In the salt tank of a water softening system, excess sodium chloride forms a layer of solid below the salt solution. According to equilibrium theory, the explanation for the constant properties of the salt solution is that
- A. the concentration of the salt solution has become constant
- B. the rate of dissolving has become equal to the rate of crystallizing
- C. sodium chloride can no longer dissociate because the solution is saturated
- D. all of the water has been used up in dissolving the salt already present in the solution

Use this information to answer questions 7 and 8.

In a chemical analysis, a solution was found to have a hydronium ion concentration of 2×10^{-11} mol/L.

7. NR When this concentration is converted to a pH, the pH of the solution is _____.

8. Based on the pH, this solution may be classified as
- A. acidic
- B. basic
- C. neutral
- D. ionic

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9. NR A cleaning solution with a pOH of 12.17 has a hydroxide ion concentration of $a.b \times 10^{-cd}$ mol/L. The values of ***a, b, c,*** and ***d*** are ___ ___ ___ ___.

10. As part of a chemical analysis of a window cleaning solution, the following evidence was obtained by testing samples of the cleaning solution with different indicators.
- Phenol red turned red.
- Both phenolphthalein and thymolphthalein were colourless.
- Bromothymol blue was blue.

The most likely pH of the solution is
- A. 10.0
- B. 9.4
- C. 8.1
- D. 7.6

11. If a solution of a strong acid is diluted by a factor of 10, the pH of the solution
- A. increases by one pH unit
- B. decreases by one pH unit
- C. increases by a factor of 10
- D. decreases by a factor of 10

12. One goal of chemical technology is to
- A. test current scientific laws and theories
- B. produce new chemical theories
- C. explain the nature of solutions
- D. solve practical problems

13. According to the modified Arrhenius theory, acids
- A. ionize into hydrogen ions
- B. react with water to produce hydronium ions
- C. react with water to produce hydrogen ions
- D. cause water to dissociate into hydrogen ions

14. A solution of sodium methanoate, NaHCOO(aq), has a pH of 8.3. Based on the modified Arrhenius theory, the chemical equation that explains this evidence is

A. $HCOO^-(aq) \rightarrow H^+(aq) + CO_2(g)$

B. $HCOO^-(aq) \rightarrow OH^-(aq) + CO(g)$

C. $HCOO^-(aq) + H_2O(l) \rightarrow H_3O^+(aq) + COO^{2-}(aq)$

D. $HCOO^-(aq) + H_2O(l) \rightarrow OH^-(aq) + HCOOH(aq)$

15. NR The following evidence was collected in an experiment to identify solutions at the same concentration and temperature.

Table 1 Experimental Evidence

Solution	Conductivity	pH
1	low	2.9
2	low	11.1
3	none	7.0
4	high	13.0
5	high	1.0
6	high	7.0

Identify, in order, the number of the solution that likely represents a

- strong acid
- weak acid
- strong base
- weak base

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16. According to the modified Arrhenius theory, a neutralization is a reaction between

A. an acid and a carbonate

B. an acid and an active metal

C. hydrogen ions and hydroxide ions

D. hydronium ions and hydroxide ions

17. When a polyprotic acid such as boric acid, $H_3BO_3(aq)$, reacts with water, the completeness of each successive reaction step

A. increases

B. decreases

C. stays the same

D. has no particular pattern

Part 2

18. **Distinguish** between the following terms:

(a) homogeneous and heterogeneous mixtures

(b) solute and solvent

(c) electrolytes and nonelectrolytes

(d) endothermic and exothermic dissolving

19. **Define** each of the following substances empirically:

(a) acid

(b) base

(c) neutral ionic substance

(d) neutral molecular substance

20. **How** is a hydronium ion different from an aqueous hydrogen ion? **How** is it similar?

21. Provide some examples from home or from your chemistry lab experience that illustrate the need to dissolve substances before they can react.

22. One brand of bottled water contains 150 mg of calcium in a 2.00 L bottle. **Determine** the concentration of calcium in

(a) parts per million

(b) moles per litre

23. A bottle of household vinegar is labelled 5% V/V acetic acid. **Determine** the minimum volume of vinegar that contains 60 mL of acetic acid.

24. Convert the following:

(a) 0.35 mol of NaCl(aq) in 1.5 L of solution into an amount concentration

(b) 25 mL of 0.80 mol/L $Mg(NO_3)_2(aq)$ into a chemical amount

(c) 0.246 mol of $NH_3(aq)$ in a 2.40 mol/L solution into a volume of solution

(d) 25.00 g of $CuCl_2(s)$ in 1.20 L of solution into an amount concentration

(e) 50.0 mL of 0.228 mol/L $Na_2CO_3(aq)$ into a mass of $Na_2CO_3(s)$

25. If water is added to a 25.0 mL sample of 2.70 g/L NaOH(aq) until the volume becomes 4.00 L, **determine** the concentration of the final solution.

26. DE Cement floors, especially in workshops, are often protected with an epoxy coating. Before applying this coating, the cement floor needs to be cleaned thoroughly. One part of this procedure usually involves an acid etching of the cement using hydrochloric acid (**Figure 1**).

(a) **Determine** the volume of 11.6 mol/L hydrochloric acid required to prepare 45 L of 3.5 mol/L solution.

(b) The preparation of this solution is potentially dangerous. **Plan** a procedure, including appropriate safety instructions, for preparing this solution.

Figure 1
Hydrochloric acid is sold as muriatic acid.

27. Write dissociation equations and calculate the amount concentration of the cations and anions in each of the following solutions:
(a) 2.24 mol/L $Na_2S(aq)$
(b) 0.44 mol/L $Fe(NO_3)_2(aq)$
(c) 0.175 mol/L $K_3PO_4(aq)$
(d) 8.75 g of cobalt(III) sulfate in 0.500 L of solution

28. **Compare** the ways in which concentrations of solutions are expressed in chemistry laboratories, consumer products, and environmental studies. Provide at least one example for each situation and include a possible reason for this choice.

29. In your own words, **describe** the rule relating the number of digits of a pH to the certainty (number of significant digits) of the hydronium ion concentration.

30. **Determine** the pH of each of the following solutions:
(a) lemon juice with $[H_3O^+(aq)] = 7.5 \times 10^{-3}$ mol/L
(b) $[HNO_3(aq)] = 2.5 \times 10^{-3}$ mol/L

31. **Determine** the hydronium ion concentration in each of the following solutions:
(a) cleaning solution with pH = 11.562
(b) fruit juice with pH = 3.5

32. **Sketch** a graph showing the relationship between pH and the hydronium ion concentration. **Describe** the relationship in a sentence.

33. State two main ways in which a theory or theoretical definition may be tested. Which method is the more stringent test?

34. **How** is the knowledge of pH useful in aquatic environments? **How** does this knowledge relate to both natural and manufactured products? Briefly **describe** two examples where knowledge of pH is used to solve practical problems.

35. DE A household cleaning solution has a pH of 12 and some fruit juice has a pH of 3.
(a) What is the hydronium ion concentration in each solution?
(b) **Compare** the concentration of hydronium ions in the fruit juice to the concentration of hydronium ions in the cleaning solution. How many times more concentrated is the hydronium ion in the juice than in the cleaning solution?

36. **Design** an experiment to determine which of six acids are strong acids and which are weak acids. Assume that you have solutions of known concentration available and all common laboratory equipment.

37. Hydrangeas (**Figure 2**) are garden shrubs that may produce blue, purple, or pink flowers. Research has indicated that their colour depends on the pH of the soil: blue at pH 5.0–5.5, purple at pH 5.5–6.0, and pink at pH 6.0–6.5. What colour of flower would be produced for each of the following soil acidities?
(a) $[H_3O^+(aq)] = 5 \times 10^{-7}$ mol/L
(b) $[H_3O^+(aq)] = 7.9 \times 10^{-6}$ mol/L

Figure 2
Hydrangea flowers

38. The term "weak" is sometimes used in non-scientific applications to mean dilute solutions. Why do we have to be careful not to use "weak" in this context when referring to acids and bases?

Use this information to answer questions 39 to 41.

Standard solutions of potassium hydrogen tartrate, $KHC_4H_4O_6(s)$, are used in chemical analysis to precisely determine the concentration of bases, such as sodium hydroxide. In one particular analysis, 100.0 mL of a 0.150 mol/L solution is required.

39. **Determine** the mass of potassium hydrogen tartrate that is required.

40. **Plan** a complete procedure for the preparation of the standard solution, including specific quantities and equipment.

41. Consult the MSDS for potassium hydrogen tartrate and sodium hydroxide and note precautions for handling these substances.

42. In a neutralization reaction of a strong acid and a strong base, how do the pH and pOH values change from their initial to their final values? **Justify** your answer by including a balanced chemical equation.

43. DE Laboratory safety rules require students to wear eye protection when handling acids, such as hydrochloric acid and sulfuric acid, yet dilute boric acid, $H_3BO_3(aq)$, is an ingredient in eye drops sold in drugstores (**Figure 3**). Although borates have been used for thousands of years in China, boric acid was not synthesized until 1702 in France. Soon after its synthesis, its mild antiseptic properties were discovered. **Explain** why some acids are more harmful than others. Your response should include

- at least two named examples of acids
- balanced chemical equations
- typical values of percent reaction with water

Figure 3
Boric acid is used in eye drops as a preservative and a buffer.

Use this information to answer questions 44 and 45.

Each of the following substances was dissolved in water to form a 0.1 mol/L solution, and then the pH of each solution was measured:

(a) $HCN(aq)$; pH = 5

(b) $HNO_3(aq)$; pH = 1

(c) $NaNO_2(aq)$; pH = 8

(d) $Sr(OH)_2(aq)$; pH = 13

44. Using the modified Arrhenius theory, write chemical equations to explain the pH evidence for each substance.

45. **Identify** the strong and weak acids and bases.

Use this information to answer questions 46 and 47.

Acids, such as nitric acid and nitrous acid, formed from the reaction of nitrogen oxides with water in the atmosphere, are components of acid deposition (such as acid rain).

nitric acid: $HNO_3(aq)$ nitrous acid: $HNO_2(aq)$

46. **Plan** an experiment to compare the acidity of nitric and DE nitrous acids. Your response should include

- an experimental design, with variables
- a list of materials required for the experiment
- a procedure indicating all steps, plus safety and disposal instructions

47. What are some negative effects of acid deposition? Provide several brief statements from a number of perspectives.

Use this information to answer questions 48 to 52.

Glycolic acid (hydroxyacetic acid, $CH_2OHCOOH(s)$) has many different uses, such as in household cleaning solutions (such as CLR®, **Figure 4**), and personal care products (such as skin creams). Aboriginal peoples used natural glycolic acids found in animal parts, such as brains, to tan hides. Glycolic acid is often used where a common strong acid would not be suitable for safety reasons. A 1.00 mol/L solution of glycolic acid has a pH of 1.92.

Figure 4
Glycolic acid is used in many household products, such as this bottle of cleaning solution.

48. Write the procedure and list the materials required to prepare glycolic acid solution and measure its pH as precisely as possible.

49. **Determine** the hydronium ion concentration of the solution.

50. Using the modified Arrhenius theory, write a chemical reaction equation to **explain** the acidity of glycolic acid.

51. If glycolic acid were a strong acid, what would its pH be? **Justify** your answer.

52. Suggest several other reasons why glycolic acid might be preferred in its many uses to a strong acid such as hydrochloric acid.

Use this information to answer questions 53 and 54.

Baking soda is one of the most versatile chemicals known. If you were to be stranded on an isolated island, baking soda would be one useful chemical to have available.

53. The acid–base properties of a baking soda solution are not easy to predict but can be explained using the modified Arrhenius theory. Knowing that a solution of baking soda turns litmus from red to blue, write chemical reaction equations, starting with solid baking soda, to explain the litmus evidence.

54. In a small group and using references, brainstorm a list of uses for baking soda. **Identify** any uses that involve acid–base reactions.

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55. What are some benefits and risks of using acidic and basic solutions in your home? Try to be specific about the risks by using WHMIS and Household Hazardous Product information. **Illustrate** your answer with some examples where you consider the benefits to exceed the risks, and other examples where you consider the risks to exceed the benefits.

56. DE Vinegar, a dilute solution of acetic acid, has a long history in human civilization. The word "vinegar" originates from a Latin word meaning "sour wine," which also indicates how it was made.

(a) Acetic acid is a common weak acid. Using the modified Arrhenius theory, write a chemical equation that explains the acidity of vinegar.

(b) If the pH of a sample of vinegar is 2.4, **predict** the hydronium ion concentration.

(c) If the sample of vinegar in (b) had a solute concentration of 1 mol/L, how does your answer to (b) show that acetic acid is a weak acid?

(d) Research the history of the uses of vinegar. **Enumerate** as many different uses as possible.

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57. The goal of technology is to provide solutions to practical problems. Most people associate technology with modern times, but technology, as practical products and processes, is as old as human civilization. Use the library or the Internet to research the modern-day precursor to Aspirin—the most widely used drug in the world—and how it was extracted and used by Aboriginal peoples in North America.

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58. Review the focusing questions on page 186. Using the knowledge you have gained from this unit, briefly **outline** a response to each of these questions.

Extension

59. Sulfuric acid, a strong acid commonly found in car batteries, is the largest-volume industrial chemical produced worldwide. Research and report, in pairs or small groups, on sulfuric acid production in industrialized countries. Your response should include

- why the volume of sulfuric acid consumed used as a measure of a country's degree of industrialization
- the names of some of the processes and products that involve sulfuric acid

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60. DE In the media, especially movies, acids are often portrayed as dangerous, with the ability to "burn through" or "eat away" almost anything. **Evaluate** this portrayal. Your response should include

- the accuracy of the typical media portrayal of acids
- justification of your evaluation with personal experience, examples, and explanations
- a list of the most dangerous acids, with reasons
- suggestions regarding how the media could more accurately portray the reactivity of acids

61. DE Many acids occur in nature. One common example is formic acid. Prepare a profile of formic acid. Your response should include

- natural occurrence in plants and animals
- general function in nature
- chemical formula
- safety and handling
- some technological applications

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62. The development of new pharmaceuticals usually involves acute toxicity tests on animals.

(a) **Define** acute toxicity. **Describe** the general testing procedure used.

(b) Animal testing is a controversial issue. **Identify** some positive and negative perspectives on this issue, including Aboriginal perspectives.

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