AP Chemistry
2000 Student Samples

The materials included in these files are intended for non-commercial use by AP teachers for course and exam preparation; permission for any other use must be sought from the Advanced Placement Program. Teachers may reproduce them, in whole or in part, in limited quantities, for face-to-face teaching purposes but may not mass distribute the materials, electronically or otherwise. These materials and any copies made of them may not be resold, and the copyright notices must be retained as they appear here. This permission does not apply to any third-party copyrights contained herein.

A.

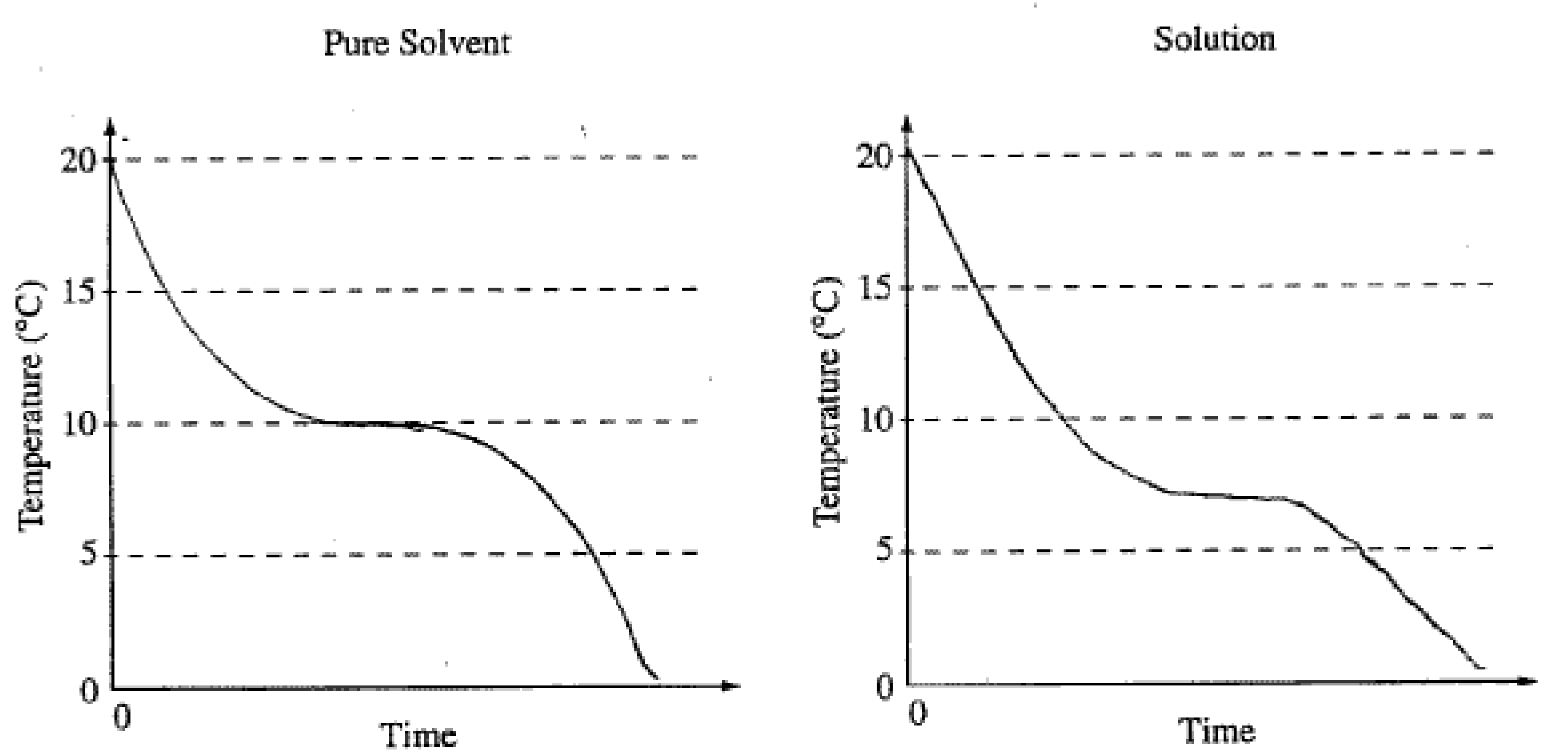
Your responses to the rest of the questions in this part of the examination will be graded on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

Answer BOTH Question 5 below AND Question 6 printed on page 20. Both of these questions will be graded. The Section II score weighting for these questions is 30 percent (15 percent each).

5. The molar mass of an unknown solid, which is nonvolatile and a nonelectrolyte, is to be determined by the freezing-point depression method. The pure solvent used in the experiment freezes at 10°C and has a known molal freezing-point depression constant, K_f. Assume that the following materials are also available.

- test tubes
- beaker
- stirrer
- stopwatch
- pipet
- graph paper
- thermometer
- hot-water bath
- balance
- ice

(a) Using the two sets of axes provided below, sketch cooling curves for (i) the pure solvent and for (ii) the solution as each is cooled from 20°C to 0.0°C.



(b) Information from these graphs may be used to determine the molar mass of the unknown solid.

(i) Describe the measurements that must be made to determine the molar mass of the unknown solid by this method.

(ii) Show the setup(s) for the calculation(s) that must be performed to determine the molar mass of the unknown solid from the experimental data.

(iii) Explain how the difference(s) between the two graphs in part (a) can be used to obtain information needed to calculate the molar mass of the unknown solid.

GO ON TO THE NEXT PAGE.

A2

B B B B B B B B B B B B B B

(c) Suppose that during the experiment a significant but unknown amount of solvent evaporates from the test tube. What effect would this have on the calculated value of the molar mass of the solid (i.e., too large, too small, or no effect)? Justify your answer.

(d) Show the setup for the calculation of the percentage error in a student's result if the student obtains a value of 126 g mol^{-1} for the molar mass of the solid when the actual value is 120. g mol^{-1}.

(b) (i) mass in g of unknown solid
mass in kg of solvent
freezing point for pure solvent
freezing point for solution

(ii) $\Delta T_f = (T_f \text{ solvent} - T_f \text{ solution})$
mol unknown = $\frac{\Delta T_f \cdot \text{kg solvent}}{i K_f}$
molar mass = $\frac{\text{g unknown}}{\text{mol unknown}}$

(iii) the horizontal part of the line is the freezing point they can be used to find ΔT_f

(c) too small because kg solvent too big → mol unknown too big → molar mass too small

(d) $\frac{6}{120} \times 100\%$ = Percent Error

GO ON TO THE NEXT PAGE.

 B1

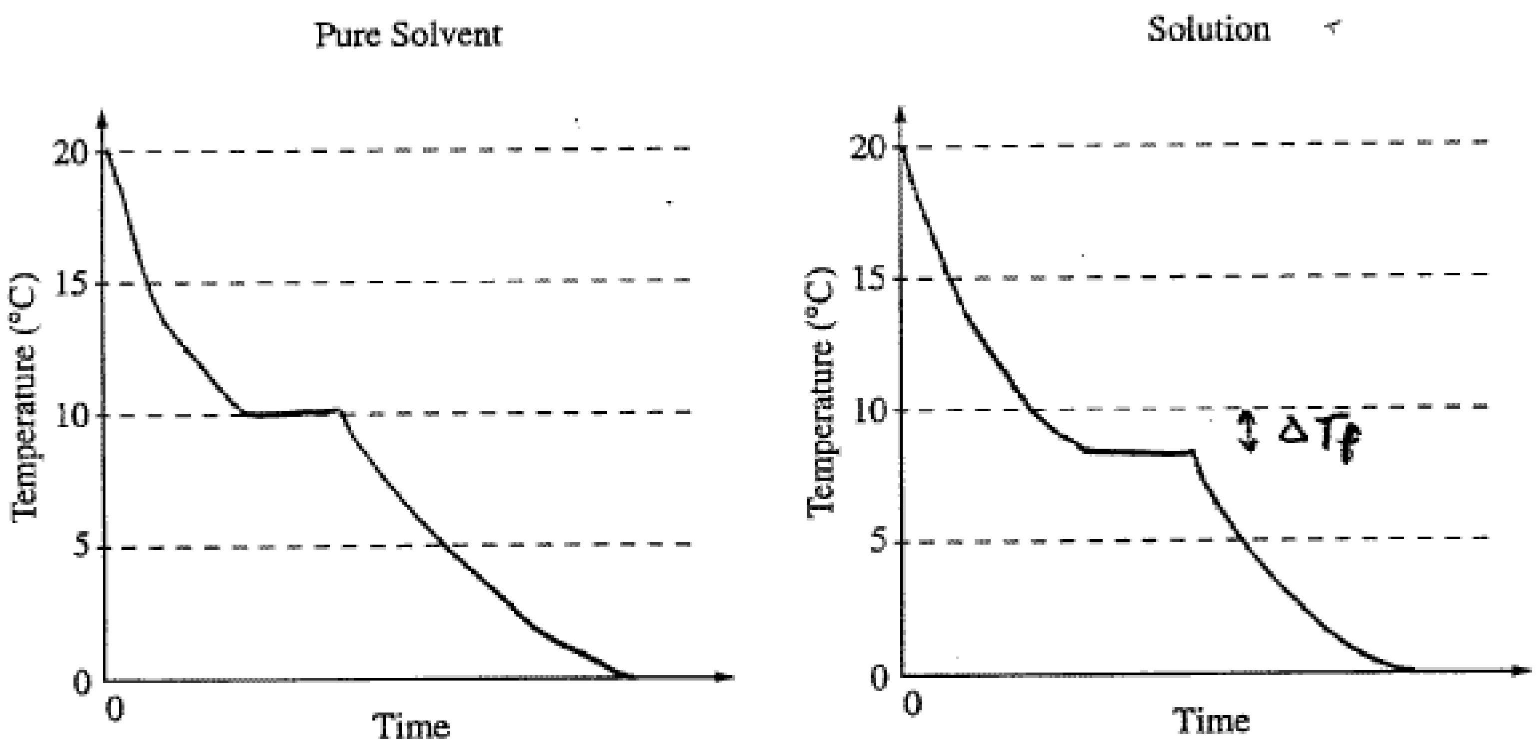
Your responses to the rest of the questions in this part of the examination will be graded on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

Answer BOTH Question 5 below AND Question 6 printed on page 20. Both of these questions will be graded. The Section II score weighting for these questions is 30 percent (15 percent each).

5. The molar mass of an unknown solid, which is nonvolatile and a nonelectrolyte, is to be determined by the freezing-point depression method. The pure solvent used in the experiment freezes at 10°C and has a known molal freezing-point depression constant, K_f. Assume that the following materials are also available.

- test tubes
- beaker
- stirrer
- stopwatch
- pipet
- graph paper
- thermometer
- hot-water bath
- balance
- ice

(a) Using the two sets of axes provided below, sketch cooling curves for (i) the pure solvent and for (ii) the solution as each is cooled from 20°C to 0.0°C.



(b) Information from these graphs may be used to determine the molar mass of the unknown solid.

(i) Describe the measurements that must be made to determine the molar mass of the unknown solid by this method.

(ii) Show the setup(s) for the calculation(s) that must be performed to determine the molar mass of the unknown solid from the experimental data.

(iii) Explain how the difference(s) between the two graphs in part (a) can be used to obtain information needed to calculate the molar mass of the unknown solid.

GO ON TO THE NEXT PAGE.

B2

(c) Suppose that during the experiment a significant but unknown amount of solvent evaporates from the test tube. What effect would this have on the calculated value of the molar mass of the solid (i.e., too large, too small, or no effect)? Justify your answer.

(d) Show the setup for the calculation of the percentage error in a student's result if the student obtains a value of 126 g mol^{-1} for the molar mass of the solid when the actual value is 120. g mol^{-1}.

b) i) mass of solute and solvent
Temp. of freezing point of solution

ii) 10°C − F.P. of Solution = ΔT_f

$\Delta T_f = K_f \cdot m$

$\Delta T_f = K_f \cdot \frac{\text{mol solute}}{\text{kg solvent}}$

mol solute = $\frac{\Delta T_f \cdot \text{kg solvent}}{K_f}$

Molar mass solute = $\frac{\text{mass of solute (g)}}{\text{mol solute}}$

iii) You can use the graph to find ΔT_f which = F.P. pure solvent − F.P. solution

c) from above mol solute = $\frac{\Delta T_f \cdot \text{kg solvent}}{K_f}$

If mass of solvent decreases → moles of solute decrease MM = $\frac{\text{mass solute}}{\text{moles solute}}$
and molar mass of solute would increase,
but since no adjustment was made, our answer
does not increase and therefore is too small.

d) $\frac{126\text{ g/mol} - 120\text{ g/mol}}{120\text{ g/mol}} \times 100\%$ = percentage error

GO ON TO THE NEXT PAGE.

C1

Your responses to the rest of the questions in this part of the examination will be graded on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

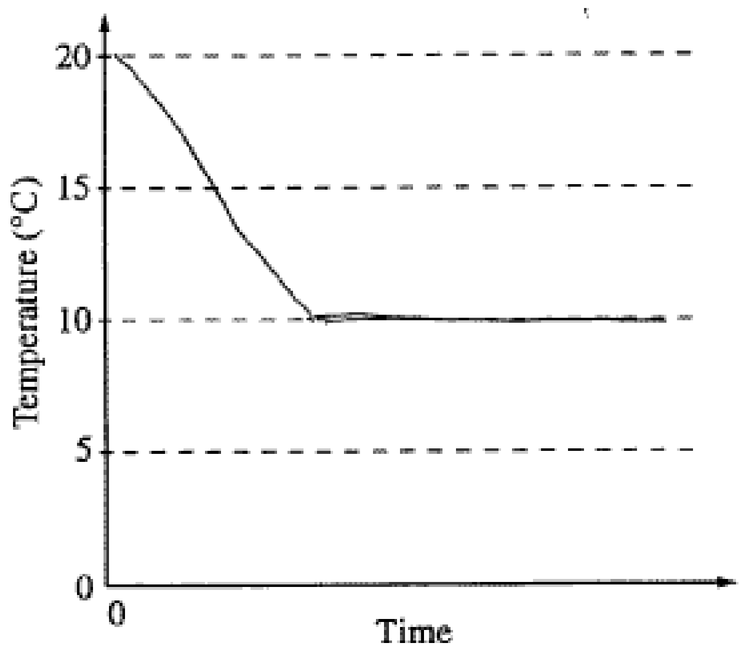
Answer BOTH Question 5 below AND Question 6 printed on page 20. Both of these questions will be graded. The Section II score weighting for these questions is 30 percent (15 percent each).

5. The molar mass of an unknown solid, which is nonvolatile and a nonelectrolyte, is to be determined by the freezing-point depression method. The pure solvent used in the experiment freezes at 10°C and has a known molal freezing-point depression constant, K_f. Assume that the following materials are also available.

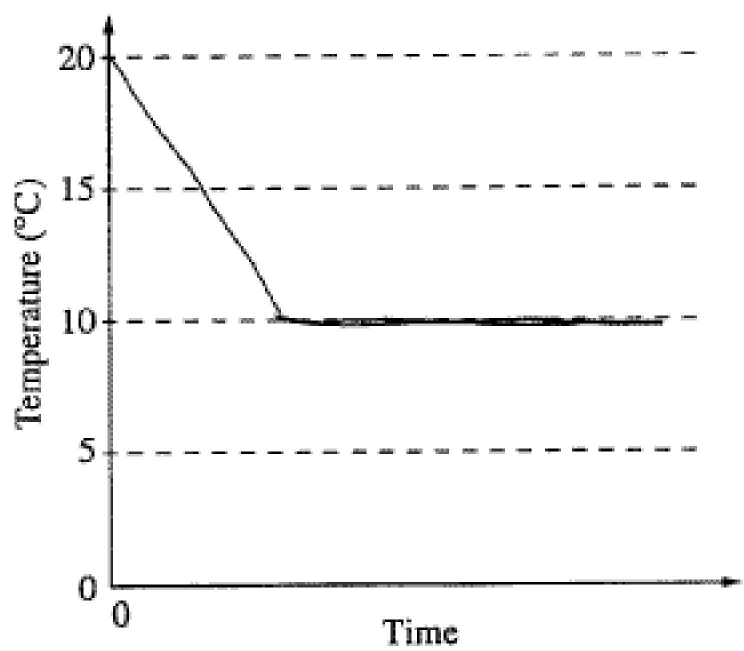
- test tubes
- beaker
- stirrer
- stopwatch
- pipet
- graph paper
- thermometer
- hot-water bath
- balance
- ice

(a) Using the two sets of axes provided below, sketch cooling curves for (i) the pure solvent and for (ii) the solution as each is cooled from 20°C to 0.0°C.

Pure Solvent



Solution



(b) Information from these graphs may be used to determine the molar mass of the unknown solid.

(i) Describe the measurements that must be made to determine the molar mass of the unknown solid by this method.

(ii) Show the setup(s) for the calculation(s) that must be performed to determine the molar mass of the unknown solid from the experimental data.

(iii) Explain how the difference(s) between the two graphs in part (a) can be used to obtain information needed to calculate the molar mass of the unknown solid.

GO ON TO THE NEXT PAGE.

(c) Suppose that during the experiment a significant but unknown amount of solvent evaporates from the test tube. What effect would this have on the calculated value of the molar mass of the solid (i.e., too large, too small, or no effect)? Justify your answer.

(d) Show the setup for the calculation of the percentage error in a student's result if the student obtains a value of 126 g mol^{-1} for the molar mass of the solid when the actual value is 120. g mol^{-1}.

b) i) the measurements needed are the freezing points of the pure solvent + of the solution. Also you need the mass of the solvent (in kg) + the solute (in g)

ii) $\Delta T = i K_f m$

from this equation, we can find the molality since that is the only unknown.

$m = \frac{\text{mol solute}}{\text{kg solvent}}$ since we know the molality + the kg of solvent, we can find the moles of the solute. Since we measured the mass of the solute, we can use $MW = \frac{g}{mol}$ to find the molecular weight of the unknown solid.

iii) the differences in the 2 graphs can be used to find the change in temperature of the freezing point (ΔT_f)

c) It would be too small because the molality would increase since the kg of solvent (in the denominator) would decrease. K_f is always negative, so the

d) $\frac{120 \text{ g mol}^{-1}}{126 \text{ g mol}^{-1}} \times 100\%$