What the particles can make

Suggested time for the entire exam: 35–50 min; adjust to local conditions.

Name _____ **Date** _____

A closed particle model contains 6 CO molecules and 4 O_2 molecules. It follows the reaction $2CO + O_2 \rightarrow 2CO_2$ until the limiting reactant runs out. All counts are molecule counts.

1. Which reactant runs out first?

- ○ A Both at exactly the same time
- ○ B CO
- ○ C O_2
- ○ D Neither can react in a closed model

2. Which count is conserved for the complete closed model?

- ○ A Number of CO_2 molecules
- ○ B Number of molecules of CO
- ○ C Total number of molecules
- ○ D Number of oxygen atoms

3. Describe or draw the final particle inventory. Verify oxygen conservation by counting atoms before and after.

Two cooling sleeves

Use the stimulus and your course knowledge.

Name _____ **Date** _____

In a simulated design test, equal volumes of water at 22 °C surround two sealed packs. After activation the water near X falls to 15 °C and near Y to 19 °C. An unactivated control stays near 22 °C. The test uses equal pack masses and equal exposure times.

4. If the pack process is the system, which direction of transfer fits the water near X?

- ○ A Energy moved from surrounding water into the pack.
- ○ B The pack added thermal energy to the water.
- ○ C Energy was destroyed as the water cooled.
- ○ D No energy moved because the pack was sealed.

5. Which result would test a separate design criterion of duration?

- ○ A The initial color of each pack
- ○ B Repeating only the starting temperature
- ○ C Counting the letters in the ingredient names
- ○ D Temperature readings at regular intervals for 45 minutes

6. Choose a pack when the sole criterion is the largest water-temperature drop at the measured time. Use both trials and explain one limit of your recommendation.

Reaction time across temperatures

Use the stimulus and your course knowledge.

Name _____ **Date** _____

At equal reactant amounts and concentrations, the times to the same visible endpoint are 140 s at 290 K, 96 s at 300 K and 65 s at 310 K. Each value is the median of three trials.

Temperature (K)	290	300	310
Time (s)	140	96	65

7. Which trial has the highest average progress per second to the endpoint?

- ○ A All rates are equal because the endpoint is the same
- ○ B 310 K
- ○ C 290 K
- ○ D 300 K

8. Why is a common endpoint important?

- ○ A It removes all measurement uncertainty.
- ○ B It ensures identical rates at every instant.
- ○ C It makes elapsed times comparable for the same amount of progress.
- ○ D It proves the reaction is reversible.

9. Evaluate the claim that raising temperature slows this process. Support the verdict numerically and connect it to a particle-level explanation.

Identifying a material

Use the stimulus and your course knowledge.

Name _____ **Date** _____

Solid M does not conduct current, but molten M conducts. Solid N conducts, and its shape can be changed by hammering. An engineer needs a material for a wire at room temperature. Assume both are solid at that temperature.

10. Which model best fits M?

- ○ A Protons moving freely through an atomic nucleus
- ○ B Free-moving electrons throughout the solid and liquid
- ○ C Ions fixed in a solid lattice that become mobile when molten
- ○ D Only neutral particles with no mobile charge in either phase

11. Which observation about N directly supports its electrical use?

- ○ A Its solid state conducts.
- ○ B It is labeled with a single letter.
- ○ C It remains a solid at room temperature by itself.
- ○ D It has been hammered once.

12. Recommend M or N for the wire using two observations. Give a particle-level account consistent with its conductivity and shape change.