Answer #261

The answer is (c): the candle flame will burn with slightly less brightness than it had before it was dropped, as seen in a slow-motion mpeg video by clicking your mouse on the photograph below.

This is a question that is often described incorrectly in physics textbooks. It has been long understood that a when a candle flame burns, the hot combustion products rise, pulling fresh air and oxygen into the flame by the process of convection. These *convection currents* then continue to feed the flame indefinitely; if they did not exist the flame would go out due to lack of oxygen.

This should be precisely the condition in the falling jug. When the jug is falling the air in the jug becomes *weightless* (The jug becomes a *local inertial frame of reference!*), so convection currents cease, fresh oxygen *should not* reach the flame, and the candle *should go out* virtually instantaneously. However, although most of this argument is true and logical (The jug does become a local inertial frame.) the candle flame does not go out. The way in which oxygen gets to the flame changes dramatically, but the flame continues to burn. In this situation the flame gets its oxygen by *diffusion*, as long as there is sufficient oxygen in the air and it can reach the flame by diffusion. The flame will stay lit indefinitely, but its character changes - it is blue in color and becomes spherical in shape except for the part adjacent to the candle. This can be seen in the photograph below of a candle flame taken in a situation of microgravity - inside a falling inertial flame - in particular, the space station. If you look carefully at the flame as the bottle drops (frame by frame) you can actually see the shape of the flame beginning to change: it becomes slightly smaller and shorter.

A candle flame in microgravity.

This experiment has been interpreted incorrectly because the flame often goes out when the container stops, due to the rapid acceleration it undergoes; this is seen in this slow-motion video, which has a few extra frames and includes the actual catch. This video shows the entire sequence in real time.

A NASA web site in which this falling candle flame photograph will be found and discussed is Microgravity Combustion Science: Candle Flames in Microgravity.

Quoting from the NASA web site:

> Under microgravity conditions, when no buoyant convection is present, molecular difffusion — a much slower process — controls the supply of oxygen and fuel vapor to the flame. Because there is no "up" or "down" in microgravity, the flame tends becomes spherical. Heat lost to the candle's wick quenches the flame's base, and the resulting flame becomes hemi-spherical. The diminished supply of oxygen and fuel in a microgravity candle flame significantly reduces how quickly the flame generates heat. Therefore, the flame's temperature is lowered to such an extent that little or no soot forms, which is evidenced by an all-blue flame.

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