Experiments contest PL8

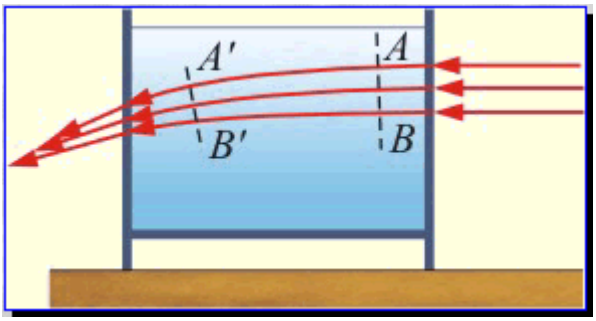
1. A red laser beam is passed through a transparent water tank just below the surface and gives a bright spot on the wall.

What will happen to the spot if we place a light bulb just above the surface?

A. the spot will stay in place
B. the spot will move downwards
C. the spot will rise

Answer: B

Explanation: The light bulb heats up the surface layers of the water. The highest layer is the warmest and has the smallest refraction index. So when the laser beam is going from one layer to a lower layer it bends downwards. When the light bulb is out the temperature balance is restoring slowly and the spot on the wall rises again.



2. Two straws, a long and a short one, are placed next to each other and attached with adhesive tape. A cotton bud is placed in each at the beginning of the experiment.

If we blow through both straws simultaneously, which cotton bud will fly further?

A. the one from the long straw
B. the one from the short straw
C. both will fly the same distance

Answer: A

Explanation: The "blowing force" on the two cotton buds is the same. But the work, which is force x distance, done on the cotton bud in the long straw is greater due to the longer distance. If more work is done there is more kinetic energy. And more kinetic energy means more speed. So the cotton bud in the longer straw will fly further.

3. An aqueous solution of sodium iodide is added to a soapy solution of hydrogen peroxide in a vessel.

What happens next?

A. the soap precipitates

B. an excellent disinfectant is obtained

C. the soap foams so much that it overflows from the vessel

Answer : C

The reaction occurs in two steps :

1st step. The hydrogen peroxide acts as an oxidant on the iodide according to the following balanced equation :

$$H_2O_2\ (l) + 2\ KI\ (aq) \rightarrow 2\ KOH\ (aq) + I_2\ (aq)$$

The reaction mechanism is as follows :

Reduction half equation	$H_2O_2 + 2\ e^-$	→	$2\ OH^-$
Oxidation half equation	$2\ I^-$	→	$I_2 + 2\ e^-$
Ionic equation	$H_2O_2 + 2\ I^-$	→	$I_2 + 2\ OH^-$
Molecular equation	$H_2O_{2\ (l)} + 2\ KI_{(aq)}$	→	$2\ KOH_{\ (aq)} + I_{2\ (aq)}$

2nd step. The basic medium catalyses the decomposition of the hydrogen peroxide.

$$2\ H_2O_2\ (l) \xrightarrow{[OH^-]} 2\ H_2O\ (l) + O_2\ (g)$$

The reaction is highly exothermic and is accompanied by an increase in disorder. The reaction is complete.

4. Powdered sodium chlorite ($NaClO_2$) is added to powdered ammonium thiocyanate (NH_4SCN).

What happens next?

A. Chlorine gas, Cl_2, is released

B. an immediate reaction occurs which is highly exothermic

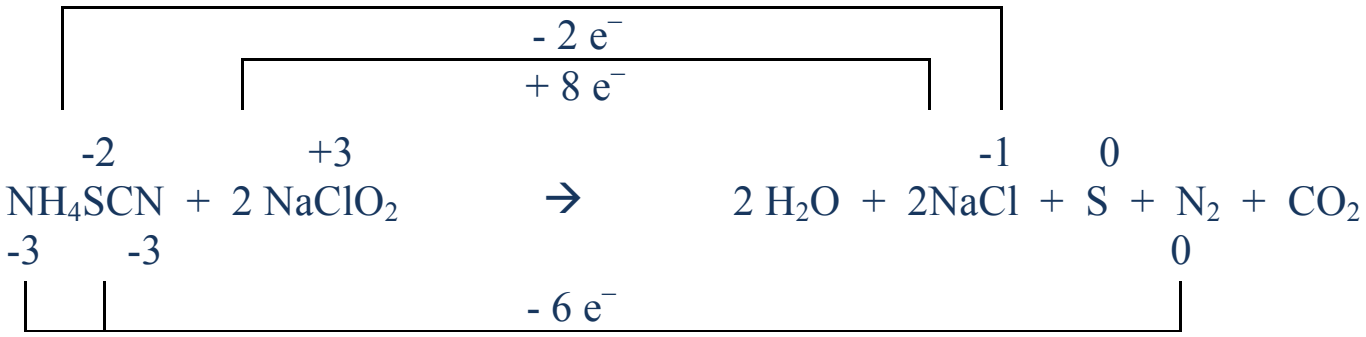
C. this reaction produces sodium hypochlorite (NaClO) which is one of the components of "eau de Javel".

Answer : B

This redox reaction is highly exothermic and is accompanied by an increase in disorder (from two solids, many gas molecules are formed):

$NH_4SCN(s) + 2\ NaClO_2(s) \rightarrow 2\ H_2O(g) + 2NaCl(s) + S(s) + N_2(g) + CO_2\ (g)$

The electron transfer can be shown as below :



5. If two green plants are exposed respectively one to red monochromatic light and the other to green monochromatic light,

A. the production of $\mathbf{O_2}$ will be identical for both plants

B. the production of $\mathbf{O_2}$ will be higher in the plant exposed to red light

C. the production of $\mathbf{O_2}$ will be lower in the plant exposed to red light

Answer: B

Photosynthetic activity is the highest in the blue purple (450 nm) and red (650 nm) region of the spectrum. Inversely the activity is the lowest in the green region (550 nm).

6. Blood pressure of a human adult is usually measured on the brachial artery of the right arm.

Among many others, the main factor(s) which determine blood pressure is/ are:

A. Vascular resistance

B. The cardiac output (flow)

C. Both cardiac flow and vascular resistance

Answer: C

Several factors are involved in blood pressure at a given point of the vascular system: the cardiac flow : the volume of blood that flows through arteries, the heart beat rate, vascular resistance : the diameter of the vessels, the elasticity of arteries walls, the tension of the smooth muscles surrounding the vessels.

7. A cylinder has a diameter of 11.5 cm. A cube of maximal dimension (diagonal equal to 11.5 cm) is placed into the cylinder. Water is then poured into the cylinder to the level of the upper face of the cube.
The cube is removed and replaced by a smaller cube.
Will the level of water :

A. Be lower than the upper face of the cube
B. Be exactly at the same level as the upper face of the cube
C. Be higher than the upper face of the cube

Answer : B

SOLUTION

Lorsque le cube a la dimension maximale permise, la mesure de son côté est $\frac{d}{\sqrt{2}}$ (d est le diamètre du cylindre, c'est-à-dire 11.5 cm) et l'eau arrive juste au ras de la base supérieure du cube.

On peut calculer exactement le volume d'eau nécessaire grâce à l'égalité suivante : $V_{cube} + V_{eau} = V_{apparent} \Leftrightarrow V_{eau} = \pi \cdot \left(\frac{d}{2}\right)^2 \cdot \frac{d}{\sqrt{2}} - \left(\frac{d}{\sqrt{2}}\right)^3$.

Le volume de l'eau (constant) vaut $\frac{d}{4\sqrt{2}}^3 \cdot (\pi - 2) \approx 306.92 cm^3$

Pour savoir quand l'eau va atteindre exactement la surface supérieure du cube de côté y, il faut résoudre l'équation

$$y^3 + \frac{d^3}{4\sqrt{2}} \cdot (\pi - 2) = \pi \cdot \left(\frac{d}{2}\right)^2 \cdot y.$$

Lorsqu'on remplace d par sa valeur 11.5, on obtient trois solutions à cette équation :

- la première solution (connue) est 8.13 cm (côté du grand cube)
- la deuxième solution est 3.30 cm (côté du petit cube)
- la troisième solution de l'équation est négative et ne peut donc pas être une solution du problème.