Solution for the Test Competition of the 5th IJSO

1. A

If the mass and volume of aluminum block are m and V, then m=? $_{al}$ V. The weight in the water is (? $_{al}$ - ? $_{water}$)Vg = 200 N. So the volume of aluminum block is V=200 N/(? $_{al}$ - ? $_{water}$)g. The weight in the unknown fluid is (? $_{al}$ - ? $_{fluid}$)Vg= 200N x(? $_{al}$ - ? $_{fluid}$)/ (? $_{al}$ - ? $_{water}$) =220 N. The density of unknown fluid is ? $_{fluid}$=1.1? $_{water}$-0.1? $_{al}$, so the specific gravity of the fluid is ? $_{fluid}$ /? $_{water}$= 1.1 -0.1 ? $_{al}$/? $_{water}$ = 1.1 – 0.1 x 2.7 = = 0.83

2. D

3. C

The current through blub A is decreased since the total resistance is increased. And the current through blub C is increased since the other path is closed.

4. B

Before the block is moving, the frictional force is same as the going down force, f_s =mg sin? .
After the block is moving, the frictional force is proportional to the normal force, f_k = μ $_k$mgcos? .

5. C

The frictional force is constant and acting in the opposite direction to the car's motion. Since the coefficients of friction are the same for both cars, the frictional force is proportional to the mass of the car (F=μmg, μ: coefficient of friction). Hence the acceleration of the car is independent of its mass (F=ma=μmg -> a=μg).

Stopping time T: 0=v_i-aT -> T=v_i/μg ; proportional to the initial speed.

Stopping distance d: d=(Average speed) x Stopping time = v_i/2 x T =v_i^2/2μg ; proportional to the square of the initial speed.

6. A

Let the radius of the droplet be r. The air resistance (f_{air} is assumed to be proportional to the cross sectional area of the droplet (? r^2). The mass of the droplet is proportional to its volume (? r^3).

The net force acting on the droplet is mg - f_{air}, and its acceleration is a=g-f_{air}/m. If the speeds of the droplets are the same, f_{air}/m is proportional to 1/r and the acceleration is larger for the droplet of the bigger size. Hence the bigger droplet reaches the ground first. Moreover, at the time point just before the droplet reaches the ground, the speed of the bigger droplet is larger, which results in the larger air resistance.

7. C

The scale reading corresponds to the normal force between the astronaut and the scale.

(a) wrong; The earth's gravity is acting on the astronaut.

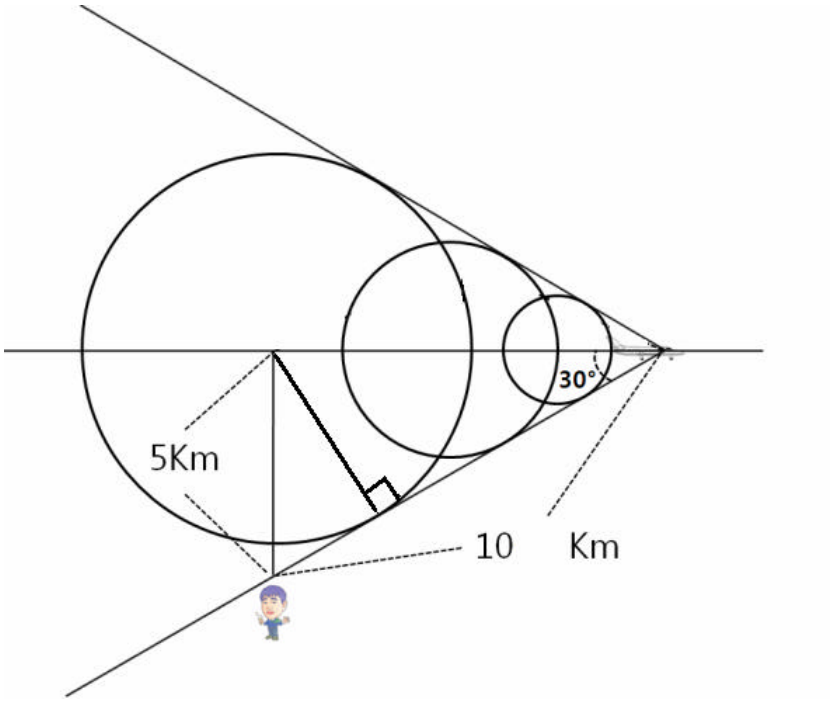
(b) wrong; The normal force between the astronaut and the scale is zero.

(c) correct

(d) wrong; The earth's gravity is acting on the scale.

8. A

The sonic boom generated by a supersonic airplane is a shock wave caused by the airplane being faster than the sound speed as shown in the figure.



9. C

A. correct; the solar radiation per unit area is inversely proportional to the square of the distance from the sun.

B. correct; as the mass of the planet increases, it is harder for the atmospheric molecules to escape from the planet.

C. correct; for lower mass planets, it is easy for the hydrogen which is the lightest molecule to escape.

D. wrong; there is not much hydrogen left inside the planet.

10. D

11. B

The solid form of most substances is more dense than the liquid phase. But, by contrast, a block of common ice will float in a tub of water because solid water is less dense than liquid water. This is an extremely important characteristic property of water. The volume of ice increases with temperature.

12. A

Even though there are 92 elements that are naturally found, only eight of them are common in the rocks that make up the Earth's outer layer, the crust. Together, these 8 elements make up more than 98% of the crust.

The 8 most common elements in Earth's crust (by mass):

46.6% Oxygen (O), 27.7% Silicon (Si), 8.1% Aluminum (Al), 5.0% Iron (Fe)

3.6% Calcium (Ca), 2.8% Sodium (Na), 2.6% Potassium (K), 2.1% Magnesium (Mg)

13. C

Under the atmospheric pressure, gaseous CO2 becomes solid when the temperature is reduced. This happens because the triple point of CO2 is at 5.11 bar. At atmospheric pressure, the liquid phase is not stable, the gas simply sublimates. Thus solid carbon dioxide is called dry ice, because it does not go through a liquid state in its phase transition at room pressure.

14. A

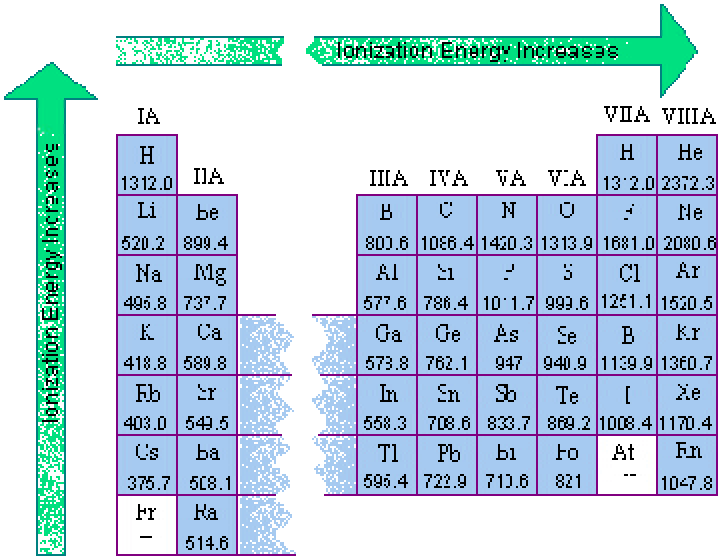
$2NH_3$ -> $N_2 + 3H_2$

The coefficients in the balanced equation stand for the relative number of moles of reactants and products gases. If the reaction goes completely, 2 moles of NH3 gas will form 4 moles of product gases.
If we assume the gases are ideal, the coefficients also stand for the relative volumes. That means 11.7 mL of reactant will from (1/2) x 11.7 mL of N2 and (3/2) x 11.7 mL of H2 gases.

15. C

By definition, the first ionization energy of an element is the energy needed to remove the outermost, or highest energy, electron from a neutral atom in the gas phase.
The process by which the first ionization energy of hydrogen is measured would be represented by the following equation. H(g) → H+(g) + e- IE = 1312.0 kJ/mol
The first ionization energy for helium is slightly less than twice the ionization energy for hydrogen because each electron in helium feels the attractive force of two protons, instead of one.
It takes far less energy, however, to remove an electron from a lithium atom
Li(g) → Li+(g) + e- IE = 572.3 kJ/mol
This can be explained by noting that the outermost, or highest energy, electron on a lithium atom is in the 2s orbital. Because the electron in a 2s orbital is already at a higher energy than the electrons in a 1s orbital, it takes less energy to remove this electron from the atom.
Although there is a general trend toward an increase in the first ionization energy as we go from left to right across this row, there are two minor inversions in this pattern. The first ionization energy of boron is smaller than beryllium, and the first ionization energy of oxygen is smaller than nitrogen.
Hund's rules predict that the three electrons in the 2p orbitals of a nitrogen atom all have the same spin, but electrons are paired in one of the 2p orbitals on an oxygen atom. Hund's rules can be understood by assuming that electrons try to stay as far apart as possible to minimize the force of repulsion between these particles. The three electrons in the 2p orbitals on nitrogen therefore enter different orbitals with their spins aligned in the same direction. In oxygen, two electrons must occupy one of the 2p orbitals. The force of repulsion between these electrons is minimized to some extent by pairing the electrons. There is still some

residual repulsion between these electrons, however, which makes it slightly easier to remove an electron from a neutral oxygen atom than we would expect from the number of protons in the nucleus of the atom.



16. C

$CaCO_3(s) + 2HCl(g) \rightarrow CaCl_2(s) + CO_2(g) + H_2O(l)$

20 g CaCO3 = 0.20 mole

HCl = 0.00090 mole

Then HCl is the limiting agent. We will expect (0.00090/2) mole of CO2 produced. That will be the 10 mL. The limiting reagent is the reactant that is completely used up during the chemical reaction. The reactant that is in excess is the reactant that is not completely used up during the chemical reaction, that is, there is some of this reactant left over.

17. B

Ka=[H3O+][A-]/[HA-]

logKa = pH + log{[A-]/[HA]}

where Ka is the dissociation constant, which is a measure of strength of an acid/base.

The half-equivalence point on a titration curve where the volume added is exactly one-half of that found at the equivalence point. The pH at the half-equivalence point is equal to the pKa of the acid being titrated. At the half-equivalence point, there is equal concentration of acid and its conjugate base

18. B

A. (incorrect). There are more gas phase molecules in the higher temperature box.

B. (correct). The ratio (B/A) of average kinetic energies of gas molecules in the two boxes is (293/283). The average kinetic energy = (3/2)RT. Therefore the temperature ("in Kelvin") ratio will be the averge kinetic energy ratio.

C. (incorrect). The average kinetic energy = $(1/2)mv^2 = (3/2)RT$. The correct statement will be v(293/283)..

D. (incorrect). The water vapor pressure inside Box A is smaller than that of Box B.

19. B

Relative humidiy (%) = {absolute humidity /saturated absolute humidity}x100

* current temperature at state A: 40 °C,
* absolute humidity at state A : 20 g/cm³
* relative humidity(%) = {20/40}x100 = 50 %

water vapor weight per volume(g/m3) vs. temperature(°C)

20. D

We can examine trends in ionic radii across a row of the periodic table by comparing data for atoms and ions that are isoelectronic (atoms or ions that have the same number of electrons).

<Radii for Isoelectronic Second-Row and Third-Row Atoms or Ions>

Atom or Ion	Radius (nm)	Electron Configuration
O2-	0.140	1s2 2s2 2p6
F-	0.136	1s2 2s2 2p6
Ne	0.112	1s2 2s2 2p6
Na+	0.095	1s2 2s2 2p6

21. Answer: (C)

Because the ink moves through the xylem, parts which have turned red first are the xylems. The arrangement of a vascular bundle in the stem cross section shows that wisteria is a dicotyledonous (a double seed-leaf) plant, In the stem cross section (I),'a' represents phloem cells, and 'b' represents xylem cells. In the leaf cross section(?), 'e' are xylem cells of veins.

22. Answer: (C)

(A) taste blindness is inherited as a recessive trait. So II-1 should be heterozygous. (B) Since III-7 has taste blindness, II-5 should be Tt. (D) The probability that II-4 and II-5 couple gives birth to the fifth and sixth babies with taste blindness in a row is 1/2 x 1/2. However, these two babies should be girls. So the final probability would be 1/2 x 1/2 x 1/2 x 1/2 = 1/16.

23. Answer: (A)

(A) was made from the 8 times of character change. (B) was 9 times, (C) and (D) were 10 times.

24. Answer: (B)

The baby from parent 2 should have O blood type. And the baby from parent 4 should have A blood type. So the baby from parent 3 will have B blood type. As all babies have different blood types, the baby from parent 1 should have AB blood type.

25. Answer: (A)

(1) is a general statement of tropical level. (2) is incorrect because rice can also give the most impact on this ecosystem in bad environmental conditions. (3) Planthopper is consumed by spiders and frogs so we can't predict the exact result. (4) Even though the number of heron increases, we can't predict the result in rice production because we don't know the role of the stinkbug. Also, we can't predict the exact result because there are 4, 5, and 6 tropical levels and we don't know the intensity of each categories (e.g. 4 tropical levels: rice < planthopper < frog < heron or 5 tropical levels: rice < planthopper < spider < frog < heron, (5) Because grasshopper only eats rice only, rice will decrease if grasshoppers increase.

26. Answer: (C)

As chromosomes are attracted to four poles, the first cleavage will result in an embryo with four cells.

27. Answer: (B)

(B) is incorrect because slower heartbeat is required for longer diving in the sea.

28. Answer: (C)

(A) inconclusive in this experiment. (B) Angle ? does not change because sun light is white light. (D) Angle ? will be smaller because blue light orient leaf position.

29. Answer: (C)

We can trace the pathway of radioactive protein to be transported after synthesis according to time course.

30. Answer: (B)

(A) a receptor-activating substance is not related to the secretion of estrogen. (C) Estrogen inhibits weight gain by binding to a receptor. (D) Ovary-extracted mouse also show obesity without treatment to inactivate the ß receptor.

P1. C

P2. B

e = 12 V, e – Ir = 11 V. r = 1 V/2 A = 0.5 0

P3. C

Power = (Electric current) x (Voltage difference). The electric current flowing in the power transmission line is 2.2kW/220V = 10A. The voltage difference between A(or B) and the input terminal is (Electric

current) x (Electric resistance)=(10A) x (1)= 10V. Therefore the voltage difference between the input terminals is 220V - 20V = 200V. Hence the voltage difference between the output terminals is 200V x 1/2 = 100V.

P4. A

The frequency with the highest intensity in the spectrum of the star light is directly related to its surface temperature (the law of blackbody radiation).

C1. C

C2. C

C3. D (F=9.6485x10^4 C/mole), Avogadro
Mol Fe/day=10000 x1000 g/55.85 = 1.791x105
Coulombs/day=(mole Fe/day) x (3 mole e/Fe) x F = 5.184x1010
Amperes=(coulombs/day) / [(24 hr/day) x (60 min/hour) x (60sec/min)] = 600000

C4. B

B1. Answer: (B)

As the temperature of incubation, 2? shows higher the hatching rate than 21? . The optimum hatching temperature is around 20? .

B2. Answer (B)

Marine fishes absorbs water through loop of Henle to keep their body fluid concentration.

B3. Answer: (D)

In aquatic ecosystems, biomass of producer can typically be less than the first level consumer because of high productivity but fast turnover of phytoplankton populations (short life span and high rate of consumption).

B4. Answer: (B)

Problem solving: The average temperature tends to decrease from the equator to the high latitude. It is important for hom eotherms to maintain body temperature opposed to the change of its environment. The size of their body has become larger to reduce the ratio of body surface area to volume, so that they are able to reduce heat loss. On the contrary, in poikilotherms, it is important to exchange the heat with the environment. The size of their body has become smaller to increase the ratio of body surface area to volume