1. Which of the following is not the reason why the third portion of a typical bioprocess flowsheet is important?
    A. Can save more money and energy
    B. Can increase the value of the intended usage
    C. Can improve the quality and concentration of the desire product
    D. Can obtain the intracellular product

2. Symbols are frequently used in bioprocess flow sheet. Referring to a simple flow sheet below, what is the meaning of the following symbols starting from (a),(b),(c), (d), (e) and (f) respectively ?
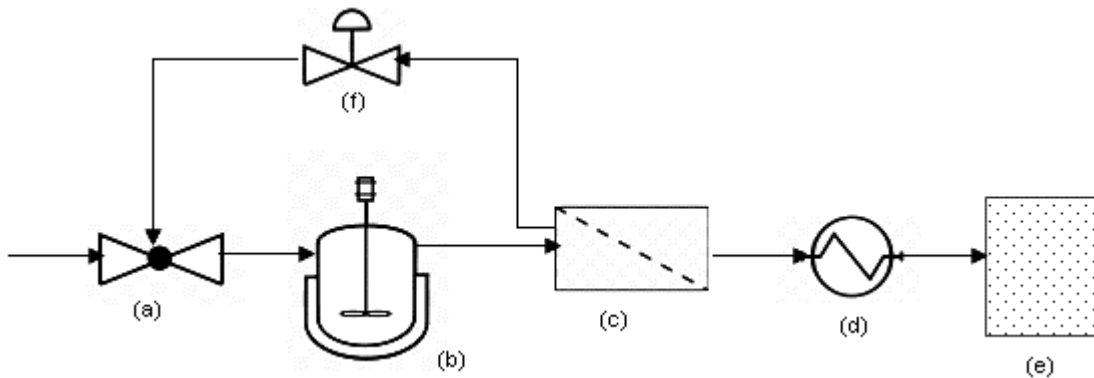
Answer	(a)	(b)	(c)	(d)	(e)	(f)
A.	Inducer valve	shaker	centrifuge	heat exchanger	vessel	valve
B.	valve	vessel	membrane	heat exchanger	vessel	heater
C.	valve	fermenter	membrane	heat exchanger	vessel	valve
D	mixer	fermenter	extractor	heat exchanger	distiller	heater

3. Based on the flow sheet above, what do you think the function of unit operation (c) and (f) is, respectively?
    A. To abstract unused solvent and change the temperature of solvent, respectively
    B. To recover cell inducer (e.g. expensive IPTG) and to control the flow of recycling stream, respectively
    C. To separate cells and to control the speed of recycling stream, respectively
    D. To separate cells and change the temperature of solvent, respectively

4. Which of the following explain the basic function of "skirt" for a bioreactor?
    A. Serves as insulator
    B. Covers the piping and valves
    C. Holds the vessel
    D. All the above answers

5. Which of the following regarding a wave bioreactor is correct?
    A. The container is disposable (meaning can throw away)
    B. It use a specially designed impeller to create "wave" that promotes mixing
    C. The sparger design is patent-protected as it creates wave bubbles

D. The jacket of the vessel looks like wave

6. Which of the following describe the major function of baffle in a bioreator?
   A. Buffering the pH of culture
   B. Maximize the mixing and help in creating almost ideal mixing condition
   C. Breaking foam
   D. Maintain the pressure inside the vessel and at the same time prevent contamination

7. Some medium cause foaming problem in bioreactor, which of the following can solve the problem?
   I. Flat-blade turbine
   II. Foam breaker
   III Adding Antiform
   IV coil jacket
   A. I, II, III, IV
   B. II, III
   C. II and IV
   D. I, II and III

8. What is the definition for "raffinate"?
   A. Liquid that pass through a membrane filter
   B. Slurries that fail to pass through a membrane filter
   C. Solvent stream that contains the product after a extraction process
   D. Aqueous stream after a extraction process

9. Which of the following is not an American Engineering (AE) unit?
   A. lbmole
   B. psi
   C. °R
   D. K

10. Which of the following is a dimensionless number?
    A. 1000×10^{89} lbm/ 0.738 M$\bullet$g
    B. 0.62846 Pa$\bullet$m/ 9978 J
    C. 0.0008×10^{-3} psi$\bullet$ft^3
    D. 75 lb$_m$/ 75 lb$_{mole}$

11. Which of the following is a steady state system?
    A. A boiling kettle
    B. A glass filled with water
    C. A evaporator
    D. A membrane-bioreactor

12. This question deals with the comparison of packed-bed bioreactor and fluidized-bed bioreactor. Which of the following are correct?

	Packed-bed bioreactor	fluidized-bed bioreactor
I	immobilize enzyme	free enzyme
II	immobilize enzyme	immobilize enzyme
III	Can be upflow or downflow	usually upflow
IV	In circulation flow (loop or recycle)	Single pass flow
V	Use stainless steel vessel	Use glass vessel

    A. All correct
    B. All correct except V
    C. II, III are correct
    D. I, II and III are correct

13. Referring to the figure below, what is the unit operation use for?

    A. Mixing device
    B. Produce cells
    C. Extract antibiotic from culture
    D. Cross flow filtration


14. Why membrane filters with pore size of 0.45 µm or 0.2 µm is normally used to filtering medium containing serum that is used for mammalian cell culture?
    A. Cost for autoclaving require more energy (cost) than filtering.
    B. Microorganism is normally bigger than 0.2 µm
    C. Membrane filters with pore size of 0.45 µm or 0.2 µm is always more economic than 1.0 µm membrane.
    D. All the above answers.

15. Referring to the following diagrams (A, B and C), the schematic drawing representing the operation of various setups for membrane filtration systems. The arrows represent the flow of fluid and the solute is represented as circular-dots. In the case of (C), impellers are built inside the housing (module) of the membrane.

(A)   **(B)**   **(C)**
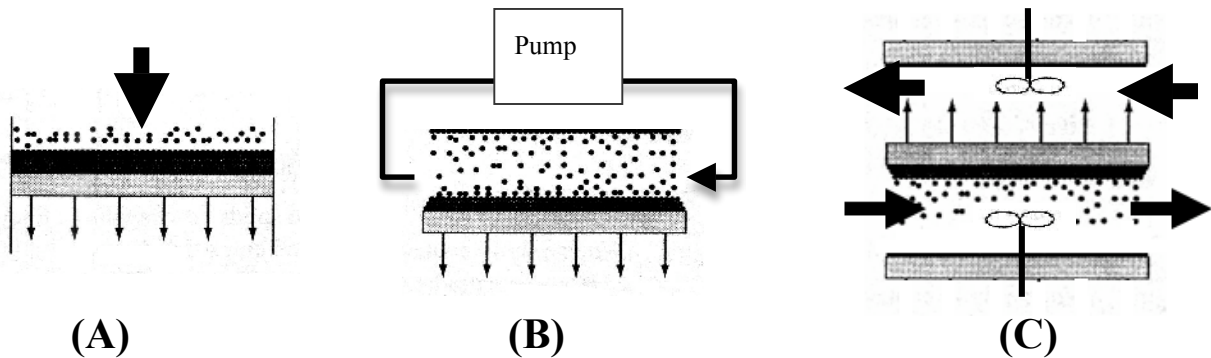
In chronological order (A then B follows by C), which of the following is the corresponding graph for the cake forming rate and flux rate for each system ?
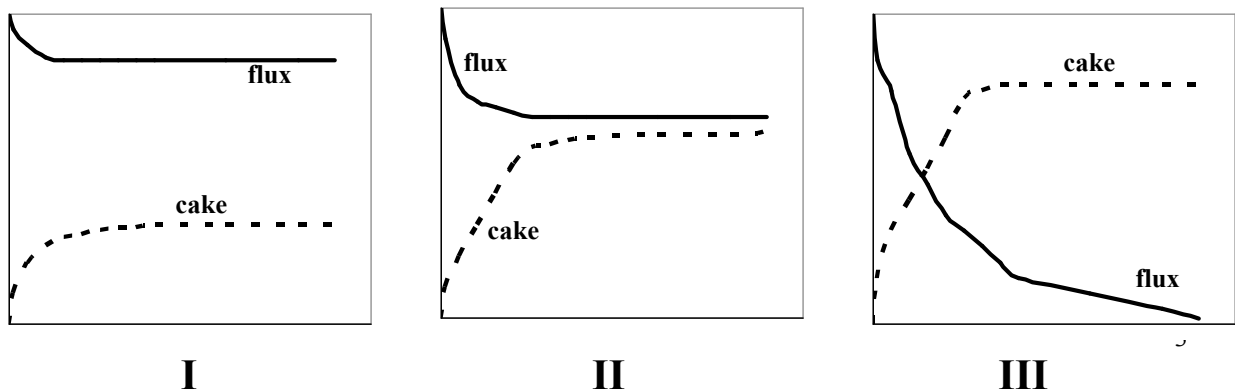
I   **II**   **III**

(a) I, II, II, respectively for system A, B and C.
(b) III, II, I, respectively for system A, B and C.
(c) II, III, I, respectively for system A, B and C.
(d) I, III, II, respectively for system A, B and C.

16.
(a) Draw a schematic diagram of a membrane bioreactor (MBR) and label accordingly
(b) Explain the system
(c) Mention 3 advantages of this system?

17.
Convert the following units to **ALL SI UNITS**.

$$\frac{1.23 \times 10^{-2} (ft)(in^2)}{(month)(min)(lb_m)(m^3)}$$

18.
The equation for Reynold number is given as $Re = D\nu\rho / \mu$,

Where   D is the diameter for a pipe,

ν is the fluid flow rate

ρ is the density of the fluid that pass through the pipe

μ is the viscosity of the fluid that pass through the pipe

Starch solution (carbon source) was pumped into a bioreactor at a rate of 1 ml/min. The temperature for the starch solution at 37°C is 0.72 centipoise (1 cP = 1.00 x 10^{-3}kg/m.s) and the density at that temperature is 1.54 g/cm^3. The diameter of the tubing attached to the inlet of the bioreactor is 0.19 inch. Is the flow inside the tubing behaved as laminar (Re<2100) or a turbulent?

19.
Human serum albumin (HSA) is applied to stabilize blood volume during surgery and during shock or burn cases. It is also used for the formulation of protein therapeutics. One gram of HSA derived from human blood costs about USD$ 2-3.50. Another disadvantage of extracting from human plasma to collect HSA is contamination of hepatitus viruses in blood. A Japanese company has designed a novel bioprocess using recombinant HSA (r-HSA), the gene of the HSA has been cloned into *Pichia pastoria* (an yeast). The manufacturing flow sheet diagram was not available, but the brief description can be found by google. Draw a flow sheet diagram based on the statement below.

> *A 50,000L jacketed stirred tank bioreactor is used to grow the P. pastoria cells. In feed preparation portion, two separate stainless vessels were used to prepare sterilize medium. In the first vessel, glycine, water, basal salts and PTM1+vitamins solution were mixed. The second vessel is used for mixing diluted methanol and PTM1. All the medium are feed into the bioreactor using pumps. After growing the cells for a desired time, the production of rHSA reached the maximum and the product will be purify. The broth will pass through a microfiltration system to remove cells, then concentrated using a cross flow filtration system. A packed-bed adsorption (PBA) is then use to affinity purify the product. The purified product is then cooled down and keeps in storage tank before formulation.*

20.

Lysine is mainly used as an animal feed additive. The annual production for the whole world is approximately 700,000 tons/year. 1 ton is 1000kg. Flow sheet below describes a simplified production of amino acid lysine in a fed-batch fermentation by a mutant of the bacterium *Corynebacterium glutamicum*. Assuming that 1 cycle of fed-batch fermentation is a month (regardless number of days), lysine purification process is only started by the end of each cycle. Therefore it is equivalent to twelve batch of production a year. Assuming that mutant *Corynebacterium glutamicum* grow very well in define medium containing only minimum salts.
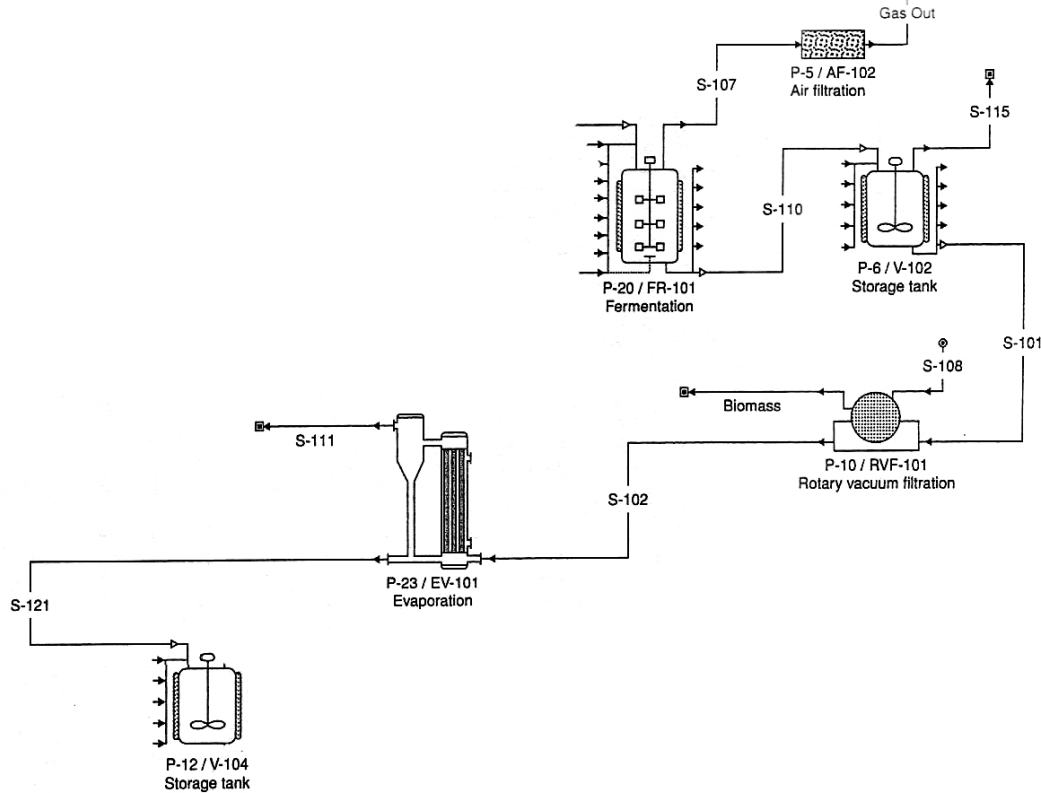
Your company BioKnight2010 Sdn. Bhd. is able to contribute 1% of total world market for lysine as your company operates 12 months a year without fail. This 1% refers to the purified form of lysine using the above flow sheet. In the storage tank P-12/V-104, it contains purified lysine and the amount of water is 7.08 ton for each batch. Evaporator P-23/EV-101 is use to remove water, efficiency for this unit is 80%. Write all your assumptions clearly (marks are given for correct assumptions).

Calculate:
(a) The (i) total weight and (ii) its composition in stream no. S-102 as well as in stream S-111.
(b) Based on some lab analysis, 30g of biomass (cells) is able to produce 60g of lysine. Assuming there is no accumulation on lysine inside evaporator and rotary vacuum filtration, determine what is the weight of biomass that forms as cake?
(c) A unit of the world-best rotary vacuum filtration system can only handle maximum 90 ton of cake and it need to be replaced after fouling. How many units of rotary vacuum filtration system do you need to purchase every year?