Name: **Enrolment No:**	

UPES

End Semester Examination, May 2025

Course: Microbial Physiology and Metabolism — **Semester : II**

Program: MSc Microbiology — **Duration : 3 Hours**

Course Code: HSMB7038 — **Max. Marks: 100**

Instructions:

1. All questions are compulsory.
2. Support answers with labelled diagrams wherever necessary.
3. Use of a scientific calculator is allowed.

S. No.	Section A Short answer questions/ MCQ/T&F (20Qx1.5M= 30 Marks)	Marks	COs
Q 1	**In the growth equation: n = 3.3 (logN – logN_0), n stands for:** a) Total population b) Initial population c) Number of generations d) Growth constant	1.5	CO1
Q 2	**The primary purpose of microbial metabolism is:** a) DNA replication b) Protein Synthesis c) RNA transcription d) Energy production	1.5	CO1
Q 3	**The phase where secondary metabolites are normally produced during growth is:** a) Lag phase b) Log Phase c) Death Phase d) Stationary Phase	1.5	CO1
Q 4	**Electron flow in the electron transport chain (ETC) is spontaneous when:** a) Electrons flow from complexes with low to high redox potentials. b) Electrons flow from complexes with high to low redox potentials. c) The flow of electrons requires energy input to drive the movement of protons. d) ATP synthesis occurs independently of electron flow.	1.5	CO1

Q 5	**A direct consequence of the proton motive force (PMF) in bacteria is:** a) Formation of NADH b) Movement of electrons through the electron transport chain c) Rotation of the flagella for bacterial motility d) Degradation of glucose to pyruvate	**1.5**	**CO1**
Q 6	**The switch between glucose and lactose metabolism in diauxic growth is controlled by:** a) Competitive inhibition b) Catabolite repression c) Feedback inhibition d) Covalent modification	**1.5**	**CO2**
Q 7	**Key feature of an anaplerotic pathway is:** a) Metabolic pathways that have both catabolic and anabolic roles b) Direction is both anabolic and catabolic c) Replenish α-ketoglutarate for amino acids d) Metabolic routes that replenish intermediates of the tricarboxylic acid (TCA) cycle	**1.5**	**CO2**
Q 8	**In the Entner-Doudoroff pathway, which of the following intermediates is produced from glucose 6-phosphate:** a) Fructose-6-phosphate b) 3-phosphoglycerate c) 6-phosphogluconate d) Pyruvate	**1.5**	**CO2**
Q 9	**In methanogenesis, the terminal electron acceptor is:** a) Oxygen b) Nitrogen c) Carbon dioxide d) Sulfate	**1.5**	**CO2**
Q 10	**Identify enzyme for microbial dissimilatory nitrate reduction to ammonium (DNRA):** a) Nitrate reductase (Nar) b) Sulfite reductase (Sir) c) Nitrite reductase (NrfA) d) Nitrous oxide reductase (NosZ)	**1.5**	**CO2**
Q 11	**Syntrophic interaction critical for anaerobic methane oxidation (ANME) is:** a) Methanogens + sulfate reducers b) Methanogens + nitrifiers c) Iron reducers + sulfur oxidizers d) Denitrifiers + cyanobacteria	**1.5**	**CO3**

Q 12	**Identify redox-pair which has the most negative reduction-potential (E_0'):** a) O_2/H_2O b) $NAD^+/NADH$ c) Fe^{3+}/Fe^{2+} d) H_2/H^+	**1.5**	**CO3**
Q 13	**During exponential phase, growth rate is:** a) same as generation time b) reciprocal of generation time c) time required for population to double d) rate of doubling population	**1.5**	**CO1**
Q 14	**In anoxic conditions, fermentative bacteria primarily use which of the following as the terminal electron acceptor:** a) Oxygen b) Nitrogen c) Organic compounds d) Sulfate	**1.5**	**CO3**
Q 15	**During dissimilatory metal reduction, the most efficient electron acceptor in terms of redox potential is:** a) Manganese (Mn^{4+}) b) Ferric iron (Fe^{3+}) c) Uranium (U^{6+}) d) Nitrate (NO_3^-)	**1.5**	**CO3**
Q 16	**Primary electron donor during anoxygenic photosynthesis is:** a) Water b) Hydrogen Sulfide c) Glucose d) Nitrate	**1.5**	**CO1**
Q 17	**Mention bacteria that is well known for directly transferring electrons to electrodes:** a) *E coli* b) *Geobacter sulfurreducens* c) *Staphylococcus aureus* d) Cyanobacteria	**1.5**	**CO2**
Q 18	**Psychrophilic microorganisms, found in extremely cold environments, often have:** a) High amounts of saturated fatty acids in their membranes to reduce fluidity b) Specialized cold-shock proteins that stabilize cellular structures c) A high proportion of unsaturated fatty acids in their cell membranes to maintain fluidity d) A reduced number of ribosomes to lower energy consumption	**1.5**	**CO3**

Q 19	**Identify the incorrect statement about dissimilatory Fe reduction by *Shewanella* sp.:** a) They can transfer electrons to insoluble Fe(III) minerals. b) They use pili for extracellular electron transfer. c) Preferred carbon source is glucose under anoxic conditions. d) They are involved in bioremediation of Uranium-contaminated sites.	**1.5**	**CO1**
Q 20	**The following is an example of a symporter:** a) Sodium-potassium pump (Na^+/K^+ ATPase) b) Sodium-glucose cotransporter (SGLT) c) Calcium pump d) Potassium channel	**1.5**	**CO1**
Section B **(4Qx5M=20 Marks)**			
Q 1	**Critically evaluate and comment on the below statement:** ***"****Aerobic respiration of a mole of glucose could produce up to 91 moles of ATP under standard conditions, though under natural cellular conditions this reaction actually produces closer to 38 moles of ATP****."***	**5**	**CO4**
Q 2	Classify and tabulate the different metabolic classes of microrganisms based on their C source, electron donor, and energy sources with representative examples of each class.	**5**	**CO2**
Q 3	Discuss the importance of reverse electron flow for purple sulfur bacteria.	**5**	**CO3**
Q 4	Explain the difference between assimilative and dissimilative metabolism with examples.	**5**	**CO1**
Section C **(2Qx15M=30 Marks)**			
Q 1	**Nitrifiers** are a group of specialized microorganisms—mainly bacteria and archaea—that play a critical role in the **nitrogen cycle** by converting **ammonia (NH_3)** into **nitrate (NO_3^-)** through a two-step process known as **nitrification**. Nitrifiers contribute to the overall health and productivity of ecosystems by ensuring the proper re-cycling of nitrogen. (a) Explain the two different steps of nitrification with examples. (b) Discuss the bioenergetics and metabolism of nitrifiers with emphasis on C source, e-donor, energy source and growth conditions. (c) Design an MPN based assay to selectively enumerate and isolate NOBs from waste-water samples.	**15** (5+5+5)	**CO3**

Q 2 | **15** | **CO2**

A pure bacterial strain (SB1) was obtained from a soil sample. SB1 was grown in batch-culture at different temperatures and absorbance (600 nm) was recorded. Absorbance readings highlighted in bold, refers to exponential growth phase of strain SB1 in below table:

Time (Hours)	Absorbance @ 600 nm			
	10°C	15°C	20°C	25°C
0	0.005	0.004	0.005	0.004
12	0.008	0.008	0.008	0.007
24	**0.018**	**0.018**	**0.018**	0.015
36	**0.055**	**0.050**	**0.025**	**0.016**
48	**0.190**	**0.140**	**0.080**	**0.018**
55	**0.370**	**0.250**	**0.150**	**0.050**
60	**0.560**	**0.400**	**0.250**	**0.090**
72	0.550	0.410	0.210	0.080
84	0.510	0.400	0.200	0.080

(8+2+5)

a) Calculate and compare specific growth rates (μ) and generation times (g) of strain SB1 at different temperatures. Comment on its optimal temperature requirements and possible habitat.

b) Explain why cardinal temperatures affect microbial growth with the help of a diagram.

c) Discuss molecular adaptations of thermophiles and psychrophiles to thrive at high or low temperatures.

Section D
(2Qx10M=20 Marks)

Q 1 | **10** (5+5) | **CO2**

a) Explain the pentose-phosphate pathway with help of a labelled schematic diagram.

b) Discuss the key functions of pentose-phosphate pathway for cellular metabolism.

Q 2 | **10** | **CO1**

Enlist and describe various direct and indirect methods for measurements of microbial growth.